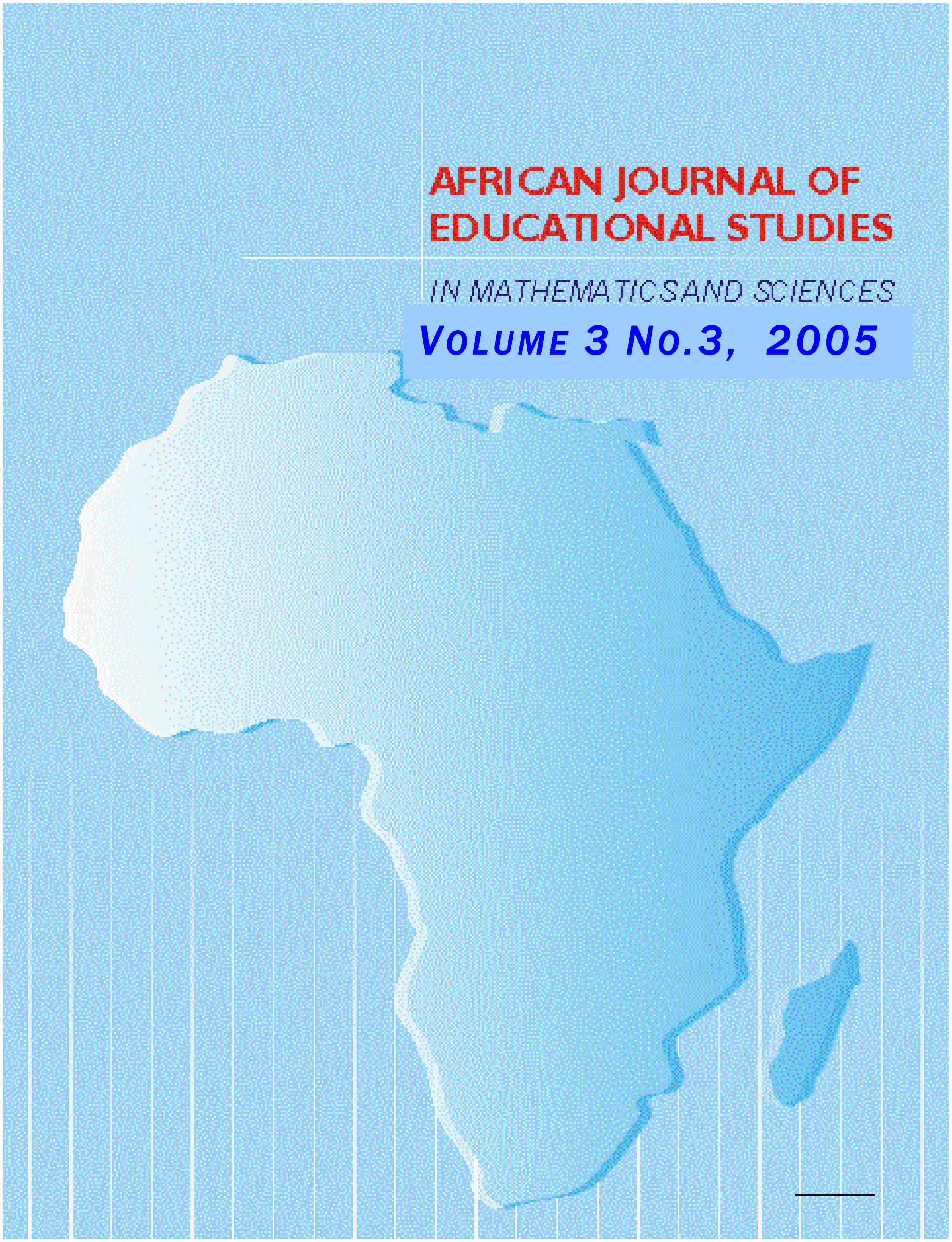
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On What Foundation is Africa Building its Science and Technology Base?: Africa's Participation in TIMSS-2003

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Abstract

School science and mathematics play a critical role in the development of scientists, engineers and technologists required for development. Although many African countries recognize this as evidenced in their declaration in Lagos (the Lagos Plan of Action) and other platforms, the teaching and learning of science and mathematics have not received the necessary support and attention as foundational subjects in the school curriculum. However, no comprehensive international study has been conducted to find out the status of science and mathematics in the different African countries. In 2003, six African countries - Ghana Egypt, Tunisia, Morocco, Botswana and South Africa - participated in an international assessment programme in science and mathematics, called the Trends in International Mathematics and Science Study (TIMSS). The study examined the performance of eighth graders in mathematics and science as well as the contextual factors that could have influenced the performance. Analyses of the data indicated that in general the African countries performed poorly. Countries in the north of Africa performed significantly better than those in sub-Saharan Africa. Generally they all performed poorly on items that involved solving non routine problems and reasoning. Examination of the context for learning science and mathematics revealed several weaknesses in the curricula of the participating African countries. It indicated that majority of the students did not have the opportunity to learn a substantial proportion of the content assessed in the TIMSS even though these were part of their intended curricula. The least use of technology (i.e. calculators and computers) in the curricula was also reported by the African countries. Recommendations are made for African governments to pay attention to the teaching of science and mathematics in the primary and secondary schools. The results of the study suggest the need to carry out an indebt examination to identify the dimensions of the problem for information that would be helpful in policy decisions to address the issue across the continent. African academics are therefore challenged to engage in systematic and collaborative research across nations to obtain reliable and valid information that will be helpful in arresting the situation.

What is TIMSS?

TIMSS is a series of studies conducted by the International Association for the Evaluation of Educational Achievement (IEA) to examine student achievement in science and mathematics, two key curriculum areas that are fundamental to the development of technologically literate societies. From the time of its inception in 1959, IEA has conducted more than 16 cross-national studies on achievement in a number of curricular areas including mathematics and science. IEA conducted its First International Mathematics Study (FIMS) in 1964 and the First International Science

Study (FISS) in 1970-71. Mathematics and science were again assessed in the Second International Mathematics Study (SIMS) and the Second International Science Study (SISS) in 1980-82 and 1983-84 respectively. From then on, IEA decided to conduct regular assessment of mathematics and science achievement every four years. Following this, a combined comparative assessment of science and mathematics, the Third International Mathematics and Science Study (TIMSS) was conducted in 1994-1995 for students at various levels of pre-tertiary education. In 1999, TIMSS (also known as TIMSS-Repeat or TIMSS-R) re-assessed grade eight students' achievement in both mathematics and science in order to measure trends in student achievement since 1995.

TIMSS-2003, re-named Trends in International Mathematics and Science Study, followed the lines of TIMSS-1999. It is the most recent in the series of IEA studies designed to measure trends in students' achievement in mathematics and science. It is a large scale study involving Years 4 and 8 students in forty-six countries. This paper examines the performance of the African countries - Botswana, Egypt, Ghana Morocco, Tunisia and South Africa - that participated in TIMSS-2003. The administration of TIMS-2003 was carried out under the auspices of IEA. The International Study Centre (ISC) in Boston College's Lynch School of Education in USA was responsible for the design and implementation of the study. Other bodies that played significant roles in ensuring the success of the study were: IEA Data Processing Centre in Hamburg, Germany; Statistics Canada, which was responsible for collecting and evaluating the sample and helping participants to adapt the TIMSS sampling design; and Educational Testing Service, which carried out the scaling of the achievement data. IEA has begun preparations for TIMSS-2007, the fourth assessment in the framework of TIMSS.

What did participation in TIMSS-2003 mean to AFRICAN COUNTRIES?

TIMSS-2003 has provided the participating countries in Africa with the opportunity to examine students' achievement in mathematics and science using an international yardstick and to compare this to that of other countries both within and beyond the continent of Africa. It also provided rich information on the context for the teaching and learning of mathematics and science in African schools which could be used to identify strengths and weaknesses in teaching and learning of these subjects. By being participant, African countries will be able to gather information at regular intervals about what our students know and what they can do in mathematics and science. It will also enable policy makers to identify the contextual variables that can be modified to bring about improvement in the learning and teaching of science and mathematics. Such cross-cultural comparison can help to discover the characteristics including the inefficiencies of our educational systems that we fail to notice because of our familiarity with the systems.

Which countries took part in TIMSS-2003?

The forty-six countries listed below participated in TIMSS-2003; the six of them from Africa are starred.

Armenia	Ghana*	Lithuania	Saudi Arabia
Australia	Hong Kong, SAR	Macedonia, Rep. of	Scotland
Bahrain	Hungary	Malaysia	Serbia
Belgium (Flemish)	Indonesia	Moldova, Rep. of	Singapore
Botswana*	Iran, Islamic Rep. of	Morocco *	Slovak Republic
Bulgaria	Israel	Netherlands	Slovenia
Chile	Italy	New Zealand	South Africa*
Chinese Taipei	Japan	Norway	Sweden
Cyprus	Jordan	Palestinian, Nat'l Auth.	Tunisia*
Egypt*	Korea, Rep. of	Philippines	United States
England	Latvia	Romania	
Estonia	Lebanon	Russian Federation	

The Conceptual and Contextual Framework for TIMSS-2003

The goal of TIMSS over the years has been to measure student achievement in mathematics and science subjects, in order to learn more about the nature and extent of achievement and the context in which it occurs. It tries to achieve this by isolating the factors directly related to student learning that can be manipulated through policy changes in, for example, allocation of school and classroom resources, curriculum and its emphasis, or instructional practices of the teachers as well as the characteristics of the students. In the studies, these broad explanatory factors underlying student achievement are classified under curriculum (Robitaille and Garden, 1996). The conceptual framework for TIMSS-2003 was therefore based on a three-strand model of the curriculum: the intended curriculum (what society would like to see taught), the implemented curriculum (what is actually taught), and the attained curriculum (what the students learn). Based on this perspective of the educational process, TIMSS assessed, through context questionnaires, factors such as national and school context, classroom characteristics, teachers, curriculum and student characteristics that are likely to influence students' learning of mathematics and the sciences. The curriculum framework used for TIMSS- 2003 has two organizing dimensions or aspects, a *content* dimension and a *cognitive* dimension, similar to those used in TIMSS-1995 and 1999. The *content* dimension defines the specific subject matter content of school mathematics and science. The *cognitive* dimension describes the many kinds of behaviour expected of students as they engage with the content in school mathematics and science. See Mullis, *et al*., (2004) and Martin, *et al.,* (2004) for details of the frameworks.

Population and Sampling Procedures

The international desired (i.e. target) population for TIMSS-2003 consisted of all students who had had eight years of education with at least two years of instruction in the language of testing prior to the test. This was the eighth grade in most countries and is referred to as the eighth-grade population. The age range was from 13 to 18 years with a mean of 15.5 years. TIMSS-2003 used standards, procedures and guidelines that ensured that country samples were of the highest quality, thus making achievement results comparable across countries. The sampling process used in selecting students in TIMSS-2003 was the same as that used in the previous TIMSS studies. The sampling plan for the selection of the participating students was developed with the help of Statistics Canada, which was also supportive in guiding the sampling process.

Instruments

The large pool of items required for a valid assessment of mathematics and science achievement based on TIMSS assessment frameworks demands that each grade eight student spends at least seven hours to answer the entire pool of test items. This time demand is not realistic as it raises issues about test reliability. To ensure that there is broad subject matter coverage without overburdening students, TIMSS used a rotated design for both the mathematics and science items. In the TIMSS framework, a design based on multiple matrix sampling technique was used to divide the item pool among a set of student booklets with each student completing one of twelve booklets containing both mathematics and science items. This means that students responded to only a subset of the larger pool of items in such a way that each item was responded to by a representative sample of students. The assignment of each student to one of the twelve test booklets was done randomly.

The test was conducted in two sessions, each session lasting 45 minutes. About 70 per cent of the test items used in the study were in multiple-choice format and accounted for about two thirds of the testing time. The remaining 30 percent were in free-response and accounted for about one-third of the testing time. The use of psychometric scaling techniques based on Item Response Theory (IRT) makes it possible for population estimates to be generated even though students do not respond to all the items or even the same items. The population estimates are obtained through the use of IRTs plausible value methodology. A comprehensive explanation of the scaling process has been given by Gonzalez, Galia and Li (2004). TIMSS-2003 used this approach to generate the overall science and mathematics scores and the scale scores for the two subjects. To obtain information on the context within which science and mathematics learning takes place, TIMSS-2003 (like TIMSS 1995 and 1999) developed a contextual framework to obtain information from curriculum specialists such as personnel from the Ministries of education of participating countries, students in participating schools, their science and mathematics teachers and their head teachers. Questionnaires were developed for this purpose.

Overview of African Students' Achievement in Science and Mathematics

In this section, the achievements of eighth graders from participating African countries in mathematics and science are compared to that of students in some of the other forty-five countries that participated in TIMSS-2003. In particular, the performance of students from the participating African countries is compared to that of countries in Asia such as Malaysia, Singapore, Japan, Chinese Taipei, Singapore and Republic of Korea that were at the same level of development as Ghana in the 1960s. Also included in the comparison is the formal colonial master and trading partner, England, as well as USA which has had a very good relationship with Africa and has been supporting its educational systems through the Agency for International Development (USAID). The results presented in this paper are largely tables extracted to showcase the achievements of eighth graders from the participating African since the detailed results can be obtained in Mullis, *et al*., (2004) and Martin, *et al.,* (2004).

The overall performance of the students from the participating African countries on the mathematics and science tests was very low. Ghana obtained low mean scale scores of 255 and 276 in science and mathematics respectively, placing the nation second from the bottom of the overall results table (Table 1).

Table 1. The overall mean science and mathematics achievement scores

Country	Overall Mean Science Achievement (SE*)	Overall Rank of country's Science scale score	Country	Overall Mean Mathematics Achievement (SE*)	Overall Rank of country's Mathematics scale score
Singapore	578 (4.3)	1	Singapore	605 (3.6)	1
Chinese Taipei	571 (3.5)	3	Chinese Taipei	585 (4.6)	4
Korea	558 (1.6)	2	Korea	589 (2.2)	2
Japan	552 (1.7)	6	Japan	570 (2.1)	5
England	544 (4.1)	**	England	498 (4.7)	**
USA	527 (3.1)	9	USA	498 (4.7)	15
Malaysia	510 (3.7)	20	Malaysia	508 (4.1)	10
International Average	474 (0.6)	-	International Average	467 (0.5)	-
Egypt	421 (3.9)	36	Egypt	406 (3.5)	37
Tunisia	404 (2.1)	39	Tunisia	410 (2.2)	36
Morocco	396 (2.5)	41	Morocco	396 (2.5)	41
Botswana	365 (2.8)	44	Botswana	366 (2.6)	43
Ghana	255 (5.9)	45	Ghana	276 (4.7)	45
South Africa	244 (6.7)	46	South Africa	264 (5.5)	46

*Standard error in parenthesis. ** Scale scores for England were not included in the ranking

Compared to other African countries that took part in the study, the performance of Ghana and South Africa were the lowest (Table 1). Egypt obtained the highest mean score in science, and Tunisia obtained the highest mean score in mathematics. All the African countries in TIMSS-2003 performed significantly lower than the international country mean. However, among the African countries, the North Africans performed significantly better than all the Sub-Saharan African countries. The poor performance of the African countries may call for the need to re-examine educational policies and practices in these countries.

African Students' Performance against the International Benchmarks

TIMSS-2003 mathematics and science achievement scales summarise Year 8 (JSS2) students' performance on test items designed to measure a wide range of student knowledge and understanding. Four points on each scale were identified for use as international benchmarks. The performance of all the students in all the countries that participated in TIMSS-2003 was taken into account when defining these benchmarks, which are described as follows:

~ *Advanced International Benchmark* corresponding to a scale score of 625,
~ *High International Benchmark* corresponding to a scale score of 550,
~ *Intermediate International Benchmark* corresponding to a scale score of 475, and
~ *Low International Benchmark* corresponding to a scale score of 400.

See Mullis, *et al*., (2004) and Martin, *et al.,* (2004) for details of characteristics of the international benchmarks of science and mathematics.

Overall, Ghana ranked 46th on the international benchmark in science. Only 13% and 3% of Ghanaian students reached the low and intermediate international benchmarks respectively (Table 2). Over 65% of the students in sub-Saharan Africa not reaching the low international benchmark implies that majority of our students have poor knowledge of basic science and mathematics facts and have weak grasp of science and mathematics concepts as well as enquiry skills that are lower level cognitive competencies. Though the situation is not as grave in the North African States,

barely half of the students are reaching the low international benchmark. It was only in Egypt that 1% of the students reached the high or advanced international benchmarks in both science and mathematics.

Table 2. Percentages of Students Reaching TIMSS-2003 International Benchmarks of Science and Mathematics Achievement in Africa and Selected Countries

	Percentage of students reaching international benchmark							
	Advanced		**High**		**Intermediate**		**Low**	
Countries	Science	Maths	Science	Maths	Science	Maths	Science	Maths
Singapore	33	44	66	77	85	93	95	99
Chinese Taipei	26	38	63	66	88	85	98	96
Korea, Rep. of	17	35	57	70	88	90	98	98
Japan	15	24	53	62	86	88	98	98
Malaysia	4	6	28	30	71	66	95	93
England	15	5	48	29	81	64	96	90
United States	11	7	41	41	75	75	93	93
International Average	6	6	25	24	54	51	78	75
Egypt	1	1	10	6	33	24	59	52
Morocco	0	0	1	1	13	10	48	42
Tunisia	0	0	1	1	12	15	52	55
Botswana	0	0	1	1	10	7	35	32
South Africa	1	0	3	2	6	6	13	10
Ghana	0	0	0	0	3	2	13	9

Countries such as Japan, Singapore, Malaysia, USA and England with almost all students reaching the low benchmark have educational systems that do excellent job of educating all its students. The educational system in Ghana where only 13 percent of the students reached the low benchmark does not appear to provide adequate preparation for its students. The low percentage of Ghanaian students reaching the higher benchmarks suggests the need to assist students to build a sound grounding in the mastery of basic knowledge and skills required to solve more cognitively demanding problems.

Contexts for Learning Science and Mathematics in African Countries

To provide a context for interpreting the achievement results, detailed information on students' backgrounds and attitudes towards mathematics and science, teachers' background, classroom characteristics and school contexts for learning and instruction, was gathered from the students taking part in the study. The mathematics and science teachers of these students, as well as their head teachers, were also made to provide information on the context in which mathematics and science learning was taking place in their schools. See Mullis, *et al*., (2004) and Martin, *et al.,* (2004) for details of the findings. In this paper, only the findings regarding teachers' qualifications and the use of technology in the mathematics and science curriculum are discussed.

Less than 10% of the grade eight students in all the African countries except Tunisia were taught by mathematics and science teachers with a university degree or its equivalent. But the results show that most of the countries with high achievement mean scores had most of their mathematics and science teachers with at least a university degree.

Use of Technology: Computers and calculators. Though the national curricula of some of the African countries contain policy statements about the use of computers and calculators in the science and mathematics curricula, over 85% of the teachers (except those in Tunisia) reported that computers were not available in their schools (Table 3 and 4).

Table 3. Computer use in the science class

Country	National Curriculum Contains Policies or Statements About the Use of Computers	Students (%) Whose Teachers Reported that Computers are not Available	Percent of Students Whose Teachers Reported on Computer Use About Half of the Lessons or More: Doing Scientific Procedures or Experiments	Studying Natural Phenomena Through Simulations	Practical Skills and Procedures	Looking Up Ideas and Information	Processing and Analyzing Data
Botswana	●	95 (2.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.3)
Egypt	●	-	-	-	-	-	-
Ghana	●	91 (2.9)	2 (1.3)	3 (1.5)	1 (0.0)	3 (1.5)	1 (1.0)
Morocco	○	86 (3.4)	0 (0.0)	0 (0.0)	1 (0.9)	2 (1.4)	1 (0.9)
South Africa	○	87 (2.4)	2 (1.0)	2 (1.2)	3 (1.4)	4 (1.5)	3 (1.3)
Tunisia	○	65 (4.4)	4 (1.6)	5 (1.9)	7 (2.1)	9 (2.4)	7 (2.3)
Singapore	●	21 (2.2)	2 (0.8)	1 (0.6)	1 (0.6)	11 (1.7)	4 (1.1)

(○ → No, ● → Yes)

In fact, the African countries are among those that make the least use of the technology (i.e. calculators and computers) in their curricula. It was observed that students' performance in the two subjects were high in countries that were encouraging the use of the technology. Singapore, for example, where the best results were reported in both subjects, practices the use of technology.

Table 4. Use of calculators in mathematics class

Country	National Curriculum Contains Policies or Statements About the Use of Calculators	Students (%) Whose Teachers Reported that Calculators are not Available	Percent of Students Whose Teachers Reported on Calculator Use About Half of the Lessons or More: Checking Answers	Doing Routine Computation	Solving Complex Problems	Exploring Number Concepts
Botswana	●	87 (4.5)	7 (2.1)	8 (2.5)	9 (2.4)	5 (1.9)
Egypt	●	0 (0.0)	46 (4.0)	64 (4.1)	52 (4.1)	36 (3.9)
Ghana	●	61 (5.0)	5 (2.0)	4 (1.7)	7 (2.4)	4 (2.0)
Morocco	○	1 (1.1)	15 (4.8)	10 (4.0)	13 (4.1)	15 (5.0)
South Africa	●	6 (1.8)	21 (3.3)	18 (2.5)	32 (3.4)	23 (3.1)
Tunisia	○	44 (4.6)	6 (2.0)	8 (2.4)	5 (1.9)	8 (2.4)
Singapore	●	0 (0.0)	63 (2.4)	63 (2.1)	65 (2.5)	32 (2.2)

(○ → No, ● → Yes)

Summary, Conclusion and Recommendation

The paper examined the performance of the African countries - Botswana, Egypt, Ghana Morocco, Tunisia, and South Africa - in TIMSS-2003. The authors' commitment to TIMSS-2003 stems probably from their desire to propel African economies through the development and use of science, mathematics and technology. Though science and mathematics are key subjects in the school system, the intended, implemented and attained curricula in these subjects are plagued with problems on the continent. The results of TIMSS-2003 have not only shown that the African countries performed significantly lower than the international country mean and those in sub-Saharan Africa ranked lowest in the whole world, but also that the African countries are among those that make the least use of the technology in their science and mathematics curricula. There is therefore the need for African governments to pay attention to the teaching of science and mathematics in the primary and secondary schools. There is also the need to carry out an indebt examination to identify the dimensions of the problem for information that would be

helpful in policy decisions to address the issue across the continent. To achieve this will require reliable and valid information obtained through systematic and collaborative research across nations.

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The nature of Formal Reasoning among Ghanaian Basic School pupils in General Science Logic Tasks

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Abstract

Many Psychologists have considered early formal thinking among adolescents as signs of normal development. As it is not known for certain at what age Ghanaian Junior Secondary School (JSS) pupils achieve formal operational capabilities, the study seeks to find out the relationship between Piagetian theory of development and the extent of formal thinking among these adolescent pupils, especially in General Science Logic tasks. This study thus used two sets of questionnaire involving "General Knowledge Logic Tasks" and "General Science Logic Tasks" based on topics chosen from the JSS science syllabus to test the logical reasoning of pupils between ages of 13 and 15 years. A total of 60 pupils were selected randomly from four junior secondary schools and tested on the questionnaire. The sample was made up of 15 pupils (with 5 from each of JSS 1 to JSS 3) from each school. They were then served with the same items. The marks they obtained on the two examinations were used to determine the extent of their formal reasoning as well as their maturity. It was found, rather surprisingly, that the older pupils did less formal reasoning than the younger ones. That is, the younger pupils in JSS 1 (age 13-14 years) performed better on the tests than those in JSS 2 (ages 14-15 years) and JSS 3 (ages 15 –16 years). It was also seen that on the average all pupils performed better on the General Knowledge tasks than on the General Science tasks, implying that pupils' formal reasoning was not subject oriented. This anomaly may be attributed to the fact that many pupils resort to rote learning and as a result forget soon afterward what they had learned while their knowledge of happenings around them appear deeper.

Introduction

Shayer and Adey (1993) have shown that pupils should be able to develop early science formal thinking in Piagetian terms as early as at age 9 years. This they attributed to the fact that secondary school science and mathematics courses require formal operational thinking. It is only such early development that would enable students to grasp the full import of the current ever-demanding senior secondary school science syllabus. The science syllabus in both junior and senior secondary schools require that learners develop new thinking skills in the learning context in which they are involved.

Case (1992) in alluding to Piagetian theory agrees that there exists a domain-independent internal operations in any child. These coherent internal operations are supposed to evolve and transform the cognitive developmental changes of the child. Piagetian theory therefore falls under what may be termed as contextual-neutral theories of cognitive development. These theories have, however, been criticized by many developmental theorists. For example, Bidell and Fischer (1992) debased the extensive reliance on the cognitive approach to education and wondered if it ever made any widespread success. The reason for his doubt is that there still existed a wide gap between developmental theory and educational practice. Thomas et al. (1992) also argued that there existed an apparent contradiction for educators who wanted to use traditional educational theories as tools for analysing specific educational processes. This assertion is based on the assumption that context-neutral theories of cognitive development separate the organization of knowledge from practice. They disputed that organization of thought and knowledge ever was primarily a property of a person. Their reason was based on the fact that specific interventions are known to have brought about contextual variation of the organization of thought and knowledge. Norman (1997) described the theory of decontextualized reasoning as archaic. He claims that content and context were crucial in determining human reasoning. However, the several arguments against context-neutral theories of cognitive development have not been replaced by alternative theories. In fact no theoretical bases have been formulated for incorporating the effect of content into reasoning. Thus content-independent developmental theories have remained the basis for interpreting and assessing human reasoning. Content has been viewed as a factor that could either facilitate or hinder logical reasoning.

Norman (1997) describes Lawson's theory of multiple hypotheses as one that comprises reasoning with more than one antecedent condition. These conditions may be classified as a scheme of immediate consequence and a scheme of activation. In terms of academic knowledge, a scheme may be considered as thought processes involved in reasoning to give an answer to a question. Thus the one with more schemes (i.e. thought processes) is said to have more formal reasoning.

The study thus tries to find out if JSS pupils in Ghana do use several thought processes in answering questions in general science and in general knowledge tasks. The sample consisted of 60 pupils from JSS1 – JSS3 chosen from four schools in the Winneba township.

The Piagetian Theory

Piaget's theory prescribes three descriptions for formal reasoning patterns which form a schemata:

Handling variables – control and exclusion of variables and classification.
Relationship between variables – ratio and proportionality; compensation and equilibrium; correlation; probability.
Formal models – constructing and using formal models and logical reasoning (Mbano, 2002, p.84).

The achievement of formal operational thinking is developmental. In this study it is a response to thinking about **variables**, and their **values** and **relationships**. The central idea here is to think about thinking - a process described by Mbano (2002) as meta-cognition.

The developmental process expects pupils who have attained the formal reasoning age to become independent thinkers who can analyze complex problems and also apply what they have learnt to real-life situations. Thomas and Emereole (2002) feel that all the knowledge and skills needed in life cannot be acquired in school. Thus one has to be a life-long learner in order to succeed in a rapidly changing world. Indeed modern technologies such as the Internet, mobile-networked technologies and the computer have been known to have improved the quality of teaching and learning (Chan and Wang cited in Thomas and Emereole, 2002). Other authors (Papert, 1993; Ward, 1994; Fletcher – Flinn and Gravatt, 1995; Poole, 1997; Ruffini, 1999) have reported positive impact of the modern technologies on students' achievement. Despite the glories of the modern technologies the maturity of the learner cannot be overlooked. This needs to happen in relation to pedagogic and contextual knowledge. This is the more reason why the attainment of formal reasoning at the appropriate age is of concern in this work.

Objectives

The question that guided the study was: "What is the nature of formal reasoning among Ghanaian Junior Secondary School pupils (ages 13 – 16 years)? Normally pupils in JSS1-JSS3 are in the age ranges of 13 to 16 years but in the sample some few pupils were found to be up to 19 years. To address the question, the study undertook the following three key activities:

(1) Administered logic tests in general knowledge to pupils in J.S.S 1 – JSS 3.
(2) Administered logic tests in general science to pupils in J.S.S.1-JSS 3.
(3) Made a comparative analysis of pupils' achievements on the two types of tests.

The assumption underlying this study is that as pupils advance to higher educational levels they move away gradually from concrete operational stage to the formal reasoning stage. It is, therefore, expected that JSS 3 pupils would perform better on the logic tests than JSS 2 and JSS 1 pupils. Also the JSS 2 pupils are expected to perform better than JSS 1 pupils on the tests. The tests were designed to find general cognitive development as well as cognitive development in science. The topics chosen for the general science test were from the JSS 1 General Science syllabus. In the junior secondary schools, students receive four hours of General Science instruction per week. Though there are no laboratory practices, teachers are expected to teach with activities and demonstrations using materials obtained from their immediate environment. Thus teachers are encouraged to create science corners so as to store materials gathered for teaching and learning. Teacher preparations programme dubbed **improvisation techniques** is one of the courses taught in the teacher training colleges. In this programme teacher-trainees are taught to construct teaching and learning materials from objects they collect from their localities. The constructivists' approach to teaching is encouraged by the J.S.S. science syllabus. This is an approach that advocates the acquisition of knowledge by exploring

one's own mental models and alternative concepts. On the other hand teacher-oriented approach to teaching is not encouraged. This in line with the findings of Ritchie, Tobin and Hook (1997) that excessive exposure referent or teacher dominated lessons (authoritarian approach) cowed students into acquiring knowledge without exploring their own mental models. Thus it may be argued that authoritarian approach to science teaching may also not allow learners to develop formal reasoning even at ages outside the Piagetian concrete operational stage.

Methodology

There were five items on each of the General Logic Tasks (GLT) and the General Science Logic Tasks (GSLT) – shown in Appendix 1. The items on the GSLT were based on topics chosen from the JSS 1 General Science Syllabus. This was done with the anticipation that the senior classes (JSS 2 and JSS 3) had learnt these topics already and that the JSS 1 pupils had also just completed the topics. Each task had three options from which pupils were to choose the one they considered the most appropriate. The options represented conclusions that could be drawn from two premises stated earlier. Only one option could be correct for an answer. For example the first task on the GLT (shown in Appendix 1) had the following two premises followed by some conclusions:

GLT task 1:

- If the school flag is flying then the national anthem was sung in the morning
- The school flag is not flying

therefore,

A. the national anthem might have been sung in the morning.
B. the national anthem was not sang in the morning.
C. no conclusion can be drawn.

The respondents were then required to draw a conclusion from the two premises and this was to be chosen from the three options given below the premises (lettered A – C). In this instance one has to make use of alternate conditions in the context of the problem in order to find the solution to the problem. There is a condition (factor) and its effect. The factor is singing the national anthem and the effect is that the school flag will be hoisted so it will be seen flying. This condition and the effect show that the two activities go together. One must then identify the antecedent of the problem. Clearly the antecedent is that the national anthem is sung first and then after that the school flag is hoisted so it is seen flying. Thus the alternate condition (the effect) cannot occur when the first condition has not occurred. The conclusion to the above item then is that since the first condition has not occurred (that is the national anthem has not been sung) then the second condition cannot occur (the school flag will not be flying). Thus the correct option for the first item above is alternative "B".

In GLT task 2, the condition is buying a ticket at the stadium gate and the effect is that you are allowed into the stadium. Here there is a condition that might affect the situation (alternate condition) and that is Kwesi might have bought the ticket for someone. Thus Kwesi may not enter the stadium. The appropriate option then is C - that is "no conclusion can be drawn".

Similarly in GLT task 3, the alternate condition affects the first condition. A goal may be disallowed despite the fact that the ball has entered the goal. This disqualification may be due to an infringement of one of the rules of the game. Thus the correct option then is C- that is “no conclusion can be drawn.”

In GLT task 4, the condition is that it does not rain and the effect is that we will go out to play. Since no alternate condition exists in the context to affect the situation, then the subsequent action is that we will go out to the field to play. Option A is then the correct answer.

In GLT task 5 the first condition is the fact that Kofi’s interest in girls makes him to be in the company of girls. The alternate or the interfering condition within the context of the task is that another boy, other than Kofi, who is also interested in girls may join the company of the girls. Thus the boy found in the company of the girls may or may not be Kofi. Thus no conclusion can be drawn so option C is the correct answer.

We now analyse the GSLT tasks (Appendix 1). The first task had the following two premises followed by some conclusions:
GLST task 1:

- “Work done is defined as the amount of energy exerted by a person pushing a load over a distance”
- “Ama pushed her Dad’s car when it would not start”
  - A. she did work.
  - B. she did not do work.
  - C. no conclusion can be drawn.

The condition (factor) here is the exertion of energy to push a load over a distance. The effect is that work is done. The alternate condition is that energy may be exerted but the load may not be moved over a distance. The effect of the alternate condition is that no work is done. It is, however, not known whether Ama was able to push the car for it to move over some distance. Thus no conclusion can be drawn (option C).

In GSLT task 2, the condition is that all organisms are living things. There is an inherent interfering condition that living things may be plants or animals. Thus specimen X needs to be classified before a conclusion can be drawn. Option C - “no conclusion can be drawn” is the correct option.

In GSLT task 3 the first condition requires that one recognises the components of carbon monoxide as oxygen and carbon. However, it is not the only gas made up of solely oxygen and carbon. Since carbon dioxide is also made up of solely carbon and oxygen atoms then no conclusion can be drawn about the gas in the jar so option C is correct.

The GSLT task 4 also had two conditions that respondents had to use to draw a conclusion about the task. Respondents were to recognize that lungs were essential for respiration but there were some animals that did not respire through lungs. The statement that lungs were important for respiraton did not preclude the fact that respiration could occur without lungs. As the animal was moving about in the bottle then it was living and

subsequently must respire. Respiration is a characteristic of living things. Thus an animal without lungs could use other means of respiration. It would thus not be expedient to conclude that once an animal did not possess lungs then it does not respire. In the circumstances the most appropriate conclusion is that the animal does not respire through lungs – option B.

The last task, GSLT task 5, also had two main conditions – that is the effect of heat on metals and the various consequences of this effect. One has to know that expansion can take various forms – it could go in linear direction or otherwise. Thus one cannot conclude that in expansion the metal must coil around an object. This is because there is no condition in the premise that implies that the metal has been positioned as to coil around an object. The only conclusion that be drawn is that since the metal has been heated so it would increase in volume – option B.

In scoring the tasks each correct option was awarded 1 mark. Thus the GLT and GSLT were each scored over a total of 5 marks. The marks for the four schools that participated were then pooled together and the mean scores on each of GLT and GSLT was determined for the three classes (Table 1). It was not necessary to find the mean for the performance of each school as the research was meant to determine a global performance of each JSS class. Thus the mean performances were calculated for all of JSS 1, JSS 2 and JSS 3 classes involved in the research. Mean plots were then made for the three classes (fig 1a) and the various ages in the sample (fig 1b) by using a computer-based mathematical software known as Statistical Package for the Social Sciences (SPSS). These graphs showed the mean performances in the GLT and the GSLT for the classes and the various ages present in the sample.

Results and Discussion

The findings show that subjects of the research differed greatly in their responses to the tasks. The choices they presented for the alternatives varied very much (the correct answers are shown with asterisks in Appendix 1). The results show that when it comes to reasoning, there is no context-neutral construct as is portrayed by Piagetian theory. A cursory look at the mean scores obtained by the various classes (Table 1) shows that the JSS 3 group had the least averages in both GLT and GSLT tasks. This is rather surprising and disappointing, as one would expect the contrary. It appears that the JSS 3 group suffered diminished memory retention - skills, concepts and strategies had diminished.

Table 1 Average performance of pupils on the GLT and GSLT tasks

	Means		
Tasks	**JSS 1**	**JSS 2**	**JSS 3**
General Logic Tasks (GLT)	2.40	2.30	2.15
General Science Logic Tasks (GSLT)	2.10	2.10	1.80

A similar work performed by Shayer et al., and cited in Mbano (2002) in which they surveyed a large representative sample of adolescents in Britain showed that only about 28 % of 14 year olds were at the early formal operational stage. Further to Shayer et al.'s work it was found that most secondary school curricula required formal operational thinking for comprehension. Since our results (Fig. 1) appear to show that our pupils who will go on to the senior secondary schools are not retaining what they learn then we could ask if these pupils can learn senior secondary school science at all.

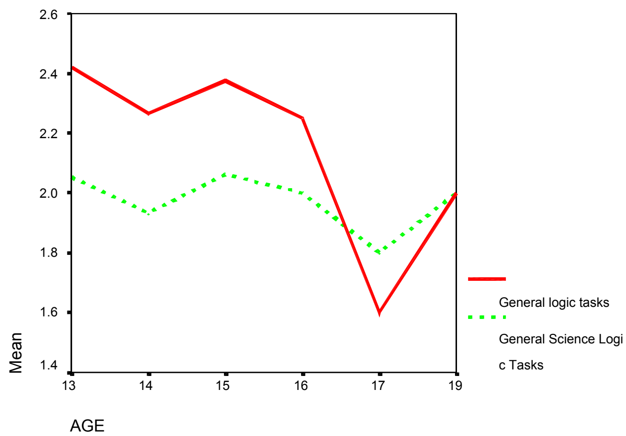

Fig. 1(a). Mean performances for the age groups

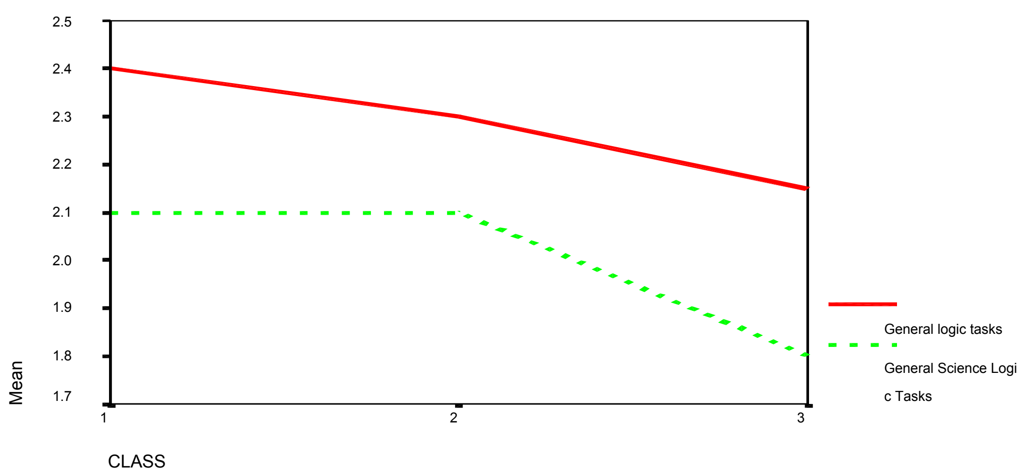

Fig. 1(b). Mean performances for the classes (JSS 1 to JSS 3)

The results show that many of the subjects were operating at the pre-formal operational stage because they could not recognize the alternate conditions in the context of the tasks. Thus such subjects used conditional logic only. The conditional pattern of reasoning does not take care of other existing conditions that might affect the conclusions that could be drawn. The task on the composition of gases (GLST 3) was the least appropriately answered. The reason may be that pupils had insufficient knowledge of nature of matter.

The problems associated with teaching and learning cannot be blamed on only one group of stakeholders in education. Teachers as stakeholders in education have a vital role to play in teaching for retention. In Ghana, however, it appears that most teachers, particularly at the basic education level, do not use the constructivists' approach to teaching. A constructivist approach to the teaching and learning process is one that expects learners to acquire essential credible knowledge and not a set of truths (Ritchie, Tobin and Hook, 1997). These authors identified three main warrants - authority, coherence and empirical evidence - as methods of acquiring credible knowledge. They found, however, that excessive content exposure referent or teacher dominated lessons (i.e. the authority approach) cowed students into acquiring knowledge without exploring their own mental models and alternative concepts. Thus students who are always exposed to authority-dominated approach to teaching may not develop formal reasoning even at ages outside the concrete operational stage. This is what appears to have happened to the subjects of this study. Their formal reasoning appears to assume a declining trend as they advance in age and also progress to higher classes. As pupils move from a lower educational stage to the higher stage they appear to forget what they had learnt earlier. Their formal reasoning assumes a **declining nature**.

The above findings are in line with the assertion of Bidell and Fischer (1992) that despite the promising nature of cognitive development theories, attempts to apply them did not meet widespread success. The failure, they attributed to a sizeable gap between developmental theory and educational practice. In Ghana, for example, the most qualified and experienced teachers are put in the senior secondary schools while the least qualified ones are put in the basic schools (i.e. primary schools and junior secondary schools). Thus teaching and learning at the basic schools are fraught with problems such as ineffective teaching and rather slow cognitive developmental changes. Many teachers in the basic schools have not benefited from in-service training for many years. They are thus glued to methodologies which when faulty remain so all the time with the attendant lack of exposure to improve their educational practices. These are teachers whose knowledge in science is even questionable, as they might not have done science to any great depth.

Conclusion and Implications

Formal operators must be able to distinguish between false and logical arguments. This is because they must be able to analyse, reconstruct or restructure the problem situation in order to generate workable hypotheses. Initiating reasoning with more than one antecedent (premise) is characteristic of formal reasoning thus concrete operational pupils will not be able to differentiate between the "probable" and the "possible". Thus concrete operational pupils cannot generate appropriate alternate conditions. On the other hand the JSS science syllabus exacts deep-seated understanding of scientific principles and laws. This means that changes in methodologies of presenting science concepts are needed for a change for the better in our junior secondary school science teaching and learning. van Driel, Beijaard and Verloop (2001) have found, from a series of research report reviews, that sufficient time, resources and continuous professional

development programmes are essential for ingraining in teachers practices that are consistent with the constructivists, approach to teaching. Since thinking about how variables affect one another in a given context is relevant to hypothesis generation, methods of teaching should be geared towards enriching learners with the skills of critical thinking to enable them analyse situations.

This study recommends similar studies with larger samples to determine whether the trend observed in this work is typical of Ghanaian pupils.

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APPENDIX 1

GENERAL LOGIC TASKS

TASK 1:

- If the school flag is flying then the national anthem was sang in the morning.
- The school flag is not flying, therefore
    - A. the national anthem might have been sung in the morning.
    - B. the national anthem was not sang in the morning.*
    - C. no conclusion can be drawn.

Task 2:

- You are allowed into the stadium if you buy a ticket at the gate.
- Kwesi bought a ticket at the gate, therefore
    - A. Kwesi is in the stadium.
    - B. Kwesi is not in the stadium.
    - C. no conclusion can be drawn.*

Task 3:

- In soccer if the football is shot into the net then a goal is scored.
- A goal has not been scored, therefore
    - A. the football has not been shot into the net.
    - B. the football has been shot into the net.
    - C. no conclusion can be drawn.*

Task 4:

- If it does not rain during break, we play on the field.
- It will not rain during break, therefore
    - A. we will play on the field.*
    - B. we will sit in the classroom.
    - C. no conclusion can be drawn.

Task 5:

- Kofi likes the company of girls.
- There is a boy standing over there with the girls, therefore
    - A. the boy is Kofi.
    - B. the boy is not Kofi.
    - C. no conclusion can be drawn.*

Note: The correct options have been marked with asterisks

GENERAL SCIENCE LOGIC TASKS

Task 1:

- Work done is defined as the amount of energy exerted by a person pushing a load over a distance.
- Ama pushed her Dad's car when it would not start, therefore
    - A. she did work.
    - B. she did not do work.
    - C. no conclusion can be drawn.*

Task 2:

- All organisms are living things.
- The specimen labeled X is an organism, therefore
    - A. it is an animal.
    - B. it is a plant.
    - C. no conclusion can be drawn.*

Task 3:

- Carbon monoxide is made up of only carbon and oxygen.
- The gas in this jar is made up of only carbon and oxygen, therefore
    - A. the gas is carbon monxide.
    - B. the gas is carbon dioxide.
    - C. no conclusion can be drawn.*

Task 4:

- Lungs are important organs for respiration.
- The animal moving in the bottle has no lungs, therefore
    - A. it does not respire.
    - B. it does not respire through lungs.*
    - C. no conclusion can be drawn.

Task 5:

- Metals generally expand when heated.
- The effect of heat on metals, therefore, is to
    - A. make them coil around another material.
    - B. Increase their volume.*
    - C. No conclusion can be drawn.

Note: The correct options have been marked with asterisks

Early Number Competencies of Children at the Start of Formal Education

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Abstract

In Ghana, like many other countries, mathematics is compulsory throughout the pre-university period of education. However, a good proportion of pupils and students at basic secondary levels of education find the subject very difficult, while at the same time, those who profess not to be good in it take pleasure in doing so. The teaching and learning of mathematics have therefore been the concern of mathematics educators, teachers, parents and indeed all those who manage education. Addition and subtraction occupy a central position in the Primary Mathematics Curriculum in Ghana. The question then is: do pupils come to formal school without sufficient knowledge in counting and strategies for solving addition and subtraction problems? The focus of this study was to investigate pupils' counting strategies and how these influenced their procedures for solving addition and subtraction tasks at the start of formal school. A qualitative case study approach was adopted for the collection of data form BS1 pupils of two primary schools in Winneba. These pupils were just beginning their formal basic education in September. Findings from the two-site case study evidence were analysed for their significance. The results of the study suggest that pupils possess varied abilities and competencies in counting when they start formal school. The findings also revealed that pupils have and demonstrate a fair knowledge of addition and subtraction concepts. Another issue that came to light was the impact the socio-economic background of the home has on pupils' early number competence. Summary and conclusions of the study were based on the evidence of these findings.

Introduction

Mathematics exists all around us. It can be regarded as a science of number, patterns, quantity and space. It is widely regarded as one of the most important school subjects and a central aspect of the school curriculum in every society. It is the view of Orton and Frobisher (1996) that "more lessons of mathematics are taught in schools and colleges throughout the world than any other subject in the curriculum" (p. 1). In Ghana, the National Curriculum defines Mathematics, together with English Language and Science, as a *core* subject, and is compulsory for all learners up to Form 3 of the Senior Secondary School (SSS) at age 18. Orton and Frobisher (1996) also note that "whenever concerns are expressed about attainment of pupils in England and Wales and comparisons, whether legitimate or not, are made with pupils in other countries, mathematics

is usually singled out as being a particularly worrying problem" (p. 1). In Ghana a lot of concern is frequently expressed about the low achievement in mathematics at both basic and secondary levels of education. Many other countries also share the same sentiments about performance in mathematics. This is revealed by the amount of research that has been and continues to be carried out in many countries with the view to improving the teaching and learning of the subject. It appears the whole world regards mathematics as a very important subject and expects that every child demonstrate a high level of attainment in the subject. The study of many disciplines/subjects depends on the knowledge, concepts and skills of mathematics.

Mathematics, apart from the fact that it forms a major part of the school curriculum, also has a variety of applications in several fields of human endeavour. In everyday life for instance, both the *schooled* and the *unschooled* depend on mathematical knowledge and ideas for transactions in commerce, industry and business, as is demonstrated by, for example, the many contributions to Harris (1991). The schooled and the unschooled refer to those who have had formal education and those have not had formal education, respectively.

As a subject taught in school, the importance of Mathematics is also emphasised by the fact that it is expected that children who may seek for jobs and those hoping to have further education must demonstrate a certain degree of attainment. In Ghana many parents may expect their children to succeed in the subject, with the hope that job opportunities and further education and training will be enhanced. This is so because the minimum requirement for employment into any skilled job includes at least a pass in core mathematics at the Senior Secondary School (SSS) level. Also, a pass in core mathematics is a requirement for entry and pursuance of any course in any tertiary or higher institution. As a result, many students who perform very well in other subjects but fail to obtain a pass in core mathematics do not gain admission to higher education or employment into any skilled job. This is evident in the large numbers of students who register and re-sit core mathematics examination.

In Ghana, even teachers who may never teach any mathematics need to pass in core mathematics at the senior secondary school before being admitted into teacher training institutions. The assumption is also made frequently that for children to grow into adults, capable of solving the problems of science, life, and the world, their level of attainment in mathematics should be high.

Mathematics as a subject taught in school, generates in many pupils and students a feeling of fear, anxiety, unease and insecurity. Responses such as: 'if you teach mathematics then you must be very brilliant', 'I never liked mathematics at school', and 'oh no, not mathematics! I am very poor at it', are very common expressions of the way other people also feel about and perceive mathematics. Mathematics is held in high esteem to the point that those who perform well at it in school are thought to be very intelligent. While those who succeed are regarded as intelligent, Orton and Frobisher (1996) argue, "those who profess not to be any good at mathematics do so all too frequently and with pride" (p. 2). It is not beneficial for the future of children in this highly technological age if a section of society is happy about not being good at mathematics. It also reflects badly on school mathematics that many people

appear to be content with their poor attainment in mathematics while in school. In Ghana even pupils in the basic education level (Upper Primary and Junior Secondary) express their fear and insecurity about mathematics. Results of Criterion Referenced Test for Primary Six pupils in mathematics revealed that the pupils had difficulty in learning the subject (MOE 1996). The harm that is inflicted, as many people take pleasure in their under-attainment in mathematics, takes a greater toll on girls (Orton and Frobisher 1996). In Ghana it appears many people do not expect girls to attain higher standards in mathematics, as very discouraging remarks are made about girls who perform very well in the subject. Orton and Frobisher (1996) further contend “if society needs a better mathematically educated adults, and if genuine equality of opportunity is to be provided, more girls need to be persuaded to consider studying mathematics for a longer period of time” (p. 3). Now, what does school mathematics entail that makes it appear so difficult to pupils? Or why do many people express so much anxiety and fear at the mention of ‘mathematics’?

The answers to these and other related questions have been that either many teachers do not teach the subject properly for pupils to understand, or the curriculum for mathematics at the early stages of children’s learning is too demanding. Yet, others think that children are not sufficiently developed or mature enough to learn mathematics, since they have to encounter lots of symbols and abstractions. The question of curriculum is always addressed by drawing up new curriculum and yet the concerns still persist.

Teachers have repeatedly been criticised for the poor standards achieved by some pupils in mathematics in the primary school (Haylock and Cockburn 1997). For example, in Ghana when the results of the first batch of students of the Senior Secondary School (SSS) system showed a very poor output in 1993, the Minister of Education, in his comments on the results, blamed the poor performance on poor teaching and bad teaching. Whether or not these criticisms are justified, a laudable aim of teachers at the basic level of education is for all pupils to achieve the highest possible standards in mathematics and move on to higher classes with as much confidence and competence in this core subject as possible. To achieve this end, teachers surely have to recognise that they have a sound and thorough understanding of the basic characteristics, abilities and competencies that their pupils possess. The first few years of schooling are very vital for laying a foundation for understanding; there are mathematical concepts and skills taught in the lower primary years that will recur throughout a child’s learning of mathematics.

From the previous section, mathematics is seen as a very important subject on the school curriculum and for entry into higher education or the world of work. However, many children who enter formal school with early number abilities and competencies soon grow to dislike mathematics. My own concerns have been agitated by the following questions:

- How do children come to hate mathematics?
- What mathematical ideas or competencies do children come to formal school with?
- Are teachers aware of the competencies children bring into formal school?

- These issues have bothered me for some time now. Answers to these questions, especially the second, form the basis of this study.

In primary schools in Ghana, especially in Basic Stages One and Two, addition and subtraction occupy a central position in the entire primary mathematics curriculum (MOE, 1998). Vergnaud (1982) argues that the concept of additive structure, of which simple addition and subtraction are most elementary examples, underlies a large portion of mathematics learnt in school and develops over an extended period of time. The transition from children's informal counting and modelling strategies developed inside or outside formal classroom instruction, to the use of memorised number facts and formal addition and subtraction algorithms according to Carpenter (1981) is a critical stage in children's learning of mathematics. Carpenter (1981) further contends that some children's later difficulty in mathematics can be traced back to initial instruction in addition and subtraction. Children's attitudes towards mathematics in general, may also depend to a large extent on the way addition and subtraction concepts are introduced to them at these early stages. Early experiences may be influential in determining children's attitude towards mathematics later on in life. Hence we need to understand children's early development of number and counting competencies as a prelude to the effective teaching of addition and subtraction. Nunes and Bryant (1996) point out, "addition and subtraction are quite complicated concepts, and until children grasp the conceptual basis of these operations they will be unable to use any procedures that are taught or any facts that they pick up at school" (p. 114).

According to Resnick and Ford (1981) when primary-age children are presented with basic addition and subtraction tasks, they tend to rely on informal counting strategies (i.e. strategies that have not been taught) to obtain their sums and differences, respectively. From my experience with young children as they solve addition and subtraction tasks, I have observed that some children count on their fingers, while others solve from known number facts or combinations, and others give immediate or spontaneous answers. I have also realised that some young children tend to make reversal errors when subtracting, in which case, they tend to subtract the smaller number from the larger number no matter the arrangement of the numbers. It is thus realised that some barriers exist to learning when children always rely on or use their informal strategies to solve addition and subtraction tasks. Difficulties also arise, if during the 'learning to count' process children learn to recite number words without reference to objects. This is referred to as *rote* learning. Such children may arrive in school able to string number words together even in their right sequence but may not have any understanding that the last number word describes the quantity of the set of objects counted.

Having realised that young children enter formal classroom with different backgrounds and capabilities in handling number, steps need to be taken, as early as possible, to develop positive attitudes to learning mathematics. One of the most effective ways of doing this is to find out the stages of development of children and the strategies they use with numbers (i.e. their counting schemes). When this has been done, teaching approaches could be designed to suit or meet each child's developmental level in order that they use more sophisticated

schemes. Ausubel (1968) argues that the most important single factor that influences meaningful learning is indeed, what the learner already knows. Having knowledge of pupils' counting strategies and procedures for solving addition and subtraction tasks at the beginning of formal schooling may provide a useful starting point for teaching.

It is in the light of the above that this study is being undertaken to explore children's counting schemes and to investigate how these strategies are used in solving addition and subtraction tasks. The main focus of my study therefore, is to identify the counting strategies used by Ghanaian children and their use of counting for solving addition and subtraction tasks at the beginning of formal schooling.

Children differ in the counting schemes they possess and this may not only limit the development of the representation of addition and subtraction concepts, but may also affect the type of problems they can individually solve (Eshun 1985, Fuson 1988). Studies by Thealer (1981) have also indicated that even when children have been given common instruction there is still a significant difference in the strategies they use in solving addition and subtraction problems.

According to Ginsburg (1977) and Baroody and Ginsburg (1990), children assimilate school arithmetic into existing cognitive structures. Indeed Baroody and Ginsburg (1990) emphasise that

> Children do not merely absorb or make a mental copy of new information; they assimilate it. That is, children filter and interpret new information in terms of their existing knowledge. Children … cannot assimilate new information that is completely unfamiliar (p. 55).

Therefore, when given addition and subtraction tasks, children attempt to solve them according to the way they organise their experience at the level of development they find themselves. Results of Baroody and Ginsburg's (1990) studies reveal that there is the need to consider individual children's strengths and weaknesses when planning instruction for any group of children no matter how 'homogeneous' they may appear to be in age (i.e. even if they are of the same age group). Thus, in designing instruction with the view that all children in the class would understand, it is essential as Brownell (1928) re-echoes that "teachers be fully informed concerning the stages of development of the children by means of continuous study … of the procedures and processes which the children employ in dealing with numbers" (p. 143). This means that it is important for teachers to find out first the level of development of their pupils, their counting skills and the strategies these pupils use in solving addition and subtraction tasks, before designing instruction to take care of their individual cognitive differences. The challenge to teachers of young children is to provide a carefully structured, activity-based curriculum, within a well-resourced environment, built around high teacher involvement and opportunities for children to learn together.

Methodology

Qualitative methods were adopted and used to collect data for the study. The main source of data for the study was pupils' clinical interviews. This was followed by observation during classroom teaching. The study sites were

located in Winneba. In choosing the study site, I relied on *purposeful sampling* technique. The logic of purposeful sampling invariably differs from the logic of probability sampling in statistics. The choice of the study sites, the school and the pupils did not depend on any random and representative manipulations. The choice of the purposeful sampling technique rests on the desire to obtain information-rich cases for the study. Any of the primary schools in Winneba could have been selected for the study. I however, undertook the fieldwork with pupils of the Basic Stage One (BS1) classes in the Methodist C & D Primary and University Practice Primary Schools.

This was a purposive sample. In qualitative research, participants (or settings, such as schools or organisations) are carefully selected for inclusion, based upon the possibility that each participant (or setting) will expand the variability of the sample (Maykut and Morehouse 1994). Purposive sampling increases the likelihood that variability common in any social phenomenon will be represented in the data, in contrast to random sampling which tries to achieve variation through the use of random selection and large sample size.

Basic Stage One (BS1) pupils, who were just beginning formal education in September, were clinically interviewed and thirty pupils from each school were selected for the writing up of the report. The pupils selected for the writing up of the study were those who demonstrated a better understanding of some unusual phenomenon or whose behaviours were particularly illuminating (Patton 1990). In sampling for qualitative research it is suggested that the most prominent and useful strategy is *maximum variation* sampling, where the researcher attempts to understand some phenomenon by seeking out persons or settings that represent the greatest differences in that phenomenon (Lincoln and Guba 1985).

The pupils were interviewed to get an insight into their counting strategies and how they used these strategies in solving addition and subtraction tasks, which involved the use of familiar materials. This occupied a major part of the fieldwork and was mainly to gather descriptive data in the participants own words and actions so that insights could be developed on how pupils' strategies. During the interviewing process, however, the pupils who were not comfortable with the activities were excused.

The tasks given to the participants involved counting of kernels in varying quantities and arrangements. Kernels are obtained from palm nuts when the outer fibre part is removed. Local children play various games with palm kernels because they are very common. The pupils also solved addition and subtraction tasks with some of the kernels screened. It should be acknowledged that as the interviewing progressed the pupils become more composed.

The pupils' clinical interviews were video-recorded since it involved the use of concrete materials, such as kernels. Maykut and Morehouse (1994) confirm that, "more recently, the use of video-tape has found a place among the collection of data gathering strategies available to researchers" (p. 112). The videotape allowed me to capture gestures, and other non-verbal actions, such as indicating acts used in counting, that were displayed by the pupils, but which were important to the study. The videotape also allowed me to view and re-view pupils' responses over and over again for further analysis.

Results and Discussion

The discussion brings together counting, addition and subtraction skills demonstrated by Basic Stage One pupils and views expressed by their teachers. These were analysed for their central themes and implications. The focus of this research was intended to find out the counting, addition and subtraction competence that pupils bring to formal school. With this in mind, pupils were asked to count a number of objects, ranging from four to nineteen, arranged in various forms on several trials. Also, activities that involved hidden objects were carried out to find out how pupils attempted to add and subtract small numbers. The data showed clearly that even though pupils are to start formal schooling at the age of six, there were pupils who were older than seven. The distribution of pupils and their ages is shown in Table 1.

Table1 Distribution of Ages and Number of Pupils selected for Study

Ages (last birthday)	5	6	7	8	9	10	11	12	13
Number of Pupils	6	18	10	9	5	4	3	3	2

The study revealed that most of all the pupils who entered BS1 after the age of six are children from poor socio-economic backgrounds. Such pupils either live with a grandmother or other extended relatives. Some of these older pupils are also from broken homes in which case their biological parents are divorced. As a result of their socio-economic background some of these older pupils had to live with other families as house-helps and baby-sitters. Most of these older pupils did not attend any pre-school. They came to start formal schooling straight from home. Most of the pupils starting Basic Education at the age of five and six years are either from homes where both parents live together or from homes where the parents are educated. The case study evidence revealed that pupils whose parents are educated and well to do are more competent in early number skills than those from poor homes. The reason may be that in well to do homes, the parents are more able to provide the right learning environment for the pupils to interact within thereby giving these pupils a head start. It is worth noting that not all pupils from poor homes are worse. Those whose attended pre-school for some time before coming to start formal school also showed more competence in counting and solving of addition and subtraction tasks.

Pupils' knowledge about Counting

The results of the study revealed that fifty-four out of sixty pupils in the sample had some knowledge about counting. Only six boys appeared to have difficulties with counting consistently when they were presented with objects in any arrangement. Pupils were deemed to have knowledge about counting if they obeyed the how-to-count principles. About 85% of the pupils who had knowledge of counting counted accurately when they were presented with sets of kernels that were displayed in a structured manner other than in a straight line i.e. in L-shape, triangular and circular. However, when the kernels were displayed in a straight line all fifty-four pupils were able to count. When the kernels were spread randomly on the table only thirty-eight pupils were able to

count accurately. The pupils who made errors were those who did not use an indicating act that could support them to count accurately. Moving objects when counting is the most efficient way of counting a set of objects more accurately. However, only eight of the pupils in the study spontaneously moved objects to count, especially when all the countable objects were visible. For some of the pupils, it was only when it was necessary, especially when the objects were many or were in a heap, that they moved the kernels as they counted. The most common indicating acts used by the pupils were pointing and touching. Three girls aged twelve, ten and eight, and a boy aged eight used the act of gazing at the set of objects and without doing anything just said the number word. Many of the pupils were very quick to realise that they had made an error in counting and so started again. This behaviour suggests that the pupils have a fair knowledge of counting and the need for accurate counting. The study also revealed that the girls in the study showed more competence in counting than the boys. The girls were relatively more accurate in their counting.

The analysis showed that the pupils from well-to-do homes, as well as, those from poor homes were all able to count using the same indicating acts. However, the few who made errors in counting were all from poor socio-economic background. These pupils did not attend pre-school due to financial constraints and therefore did not have the enabling environment that could have aided them to consolidate their counting skills.

Pupils' knowledge of Addition

At the time of the fieldwork the pupils were just beginning basic education and so it was believed that no formal algorithms had been taught. The analysis of the data revealed that the pupils had knowledge of addition. The pupils had the knowledge that addition increases the number of objects in a set. When they were asked to tell the number of objects that will result if some more were added many of them were able to give the correct responses. Even those who could not give the correct answers still gave answers that showed that the original quantity had increased in number.

The analysis of the data also showed that the pupils had various strategies for solving addition tasks. These ranged from modelling with perceptual objects as the most primitive strategy through using counting-on to derived facts, which I refer to as thinking strategies. Each pupil in the study used the most sophisticated strategy but when the task was a little difficult those with advanced strategies quickly fell back on less sophisticated strategies. The bottom line is that the pupils had a good knowledge of the concept of addition situations and made a useful attempt to use a strategy to enable him or her to solve the task.

A situation that posed a bit of a difficulty for the pupils was telling the numerical difference between two sets. When the pupils were asked to tell how many more kernels they would add to the smaller of two sets in order to make the sets equivalent, many of them could not respond correctly even though they were able to identify which of the two sets contained more objects. The pupils who used the counting-all strategy for solving addition problems could not solve 'equalise and compare' problems. These pupils were able to solve 'combine'

problems by counting the two entities together to obtain the final answer. Pupils who used counting-on and thinking strategies were able to solve equalise and compare problems.

Pupils' knowledge of Subtraction

The analysis of the case study data revealed that the pupils had knowledge of the concept of subtraction. They knew that subtraction brought about a decrease in the number of objects in the original set. When they had counted a set of kernels the pupils were asked to tell the number of kernels that would be left if some of the kernels were taken from the set. Almost all the pupils in the sample were able to answer correctly. Even those few who gave wrong responses by their answers indicated that they knew what subtraction was all about.

In solving subtraction tasks, many of the pupils used the "separating from" strategy in which case they modelled the task before giving an answer. Some of the pupils could not answer any question correctly without counting the objects left. Other pupils made representations of the tasks on their fingers before giving their answers. As a result pupils took a longer time before responding to subtraction tasks. There was another group of pupils who used "sequence counting-on" strategy to solve addition tasks. These pupils, in responding to subtraction tasks, used their fingers in keeping track of the hidden objects. There were yet other pupils who used thinking strategies to solve subtraction tasks. Such pupils used their own strategies, which helped them to solve tasks involving subtraction. Those pupils who could not answer equalise and compare problems involving addition could also not respond to equalise and compare problems involving subtraction. Those who were able to answer equalise and compare problems involving addition were also able to answer the subtraction problems correctly.

Conclusion

The analysis of the data revealed that generally, as pupils begin formal education, they have a lot of skills, strategies and competencies in the area of early number. Whether and how teachers build on what pupils know already is not very clear. It is recommended that research be done to investigate teachers' knowledge about the pupils they teach and how the background and competence of pupils influence their teaching approaches.

Finally, I have presented a summary of the main findings of the research highlighting some of the strategies and procedures pupils used in counting and solving addition and subtraction tasks as they start formal schooling. The findings revealed that pupils do enter formal school with some knowledge on early number concepts and strategies. Some of the pupils were also quick to realise their mistakes and correct them. The study further revealed that there was a wide age range of pupils in the BS1 classroom. Generally, the study revealed that children begin formal education with their own knowledge and concepts, strategies and procedures involving early number. It is my fervent hope that if teachers and other educationists become aware of these competencies in children, more appropriate teaching approaches would be adopted in order to improve the quality of mathematics teaching in schools.

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Addressing Poverty in Ghana: The Role of Home Economics Education

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Abstract

This paper focused on the role Home Economics education can play in poverty alleviation. It identifies poor education as a serious major contributing factor to poverty. It highlights the problems of poverty and concludes by suggesting measures for coping with the problems and alleviating poverty in Ghana.

Introduction

Poverty is a problem of the whole world, both developed and developing nations. The International Fund for Agricultural Development (1992) supports this by saying that "disparity of income and life has been a fact of humanity since the beginning of society; the poor have always out numbered the rich." According to the Ghana Poverty Reduction Strategy (GPRS) 2002 - 2004, over the past ten years, Ghana has experienced growing and deepening poverty an evidence of intensification of vulnerability and exclusion among some areas, especially in the north of the country and the central region. Five out of ten regions in Ghana had more than 40% of their population living in poverty in 1999. The GPRS (2002) continue that the worst affected being the three northern savannah regions (the Upper East, Upper West and Northern Regions). Nine out often people in the Upper East, eight out often in Upper West, seven out of ten in Northern Region and five out of ten in Central and Eastern Regions were classified as poor in 1999. Ghana's economy, since the early 1990s, has been characterised by high rates of inflation, high interest rates, continuous depreciation of the cedi, dwindling foreign reserves, excessive public debt and stagnant economic growth (GPRS, 2002). As a result, both growth and incomes have remained stagnant. This stagnation in growth of the economy in the 1990s has produced less than acceptable levels of poverty reduction.

Poverty is endemic in Ghana and its impact can be seen all over the country. A number of poverty indicators, characterised by low income, low economic growth, low productivity, ineffective educational system, unemployment, worker-retrenchment, violence, crime and corruption are prevalent. If these characteristics are not properly addressed, indications are that they will persist. Measures so far taken by the government on poverty alleviation have not yielded the desired results. Some of these include Operation Feed Yourself (OFY); Economic Recovery Programme (ERP); Structural Adjustment Programme (SAP); Programme of Action to Mitigate the Social Cost of

Adjustment (PAMSCAD); and now Ghana had to join the Highly Indebted Poor Countries (HIPC) initiative to reduce foreign debts. Some individuals have even accepted that there is nothing they can do to come out of their wretched situation and have given up. Life does not have to be that bad. Enyi and Akpan (2002) express similar situation in Nigeria which happens to be a former British colony like Ghana.

The Concept of Poverty

Poverty is lack of means to satisfy the basic necessities of life. The World Bank (1997) explains that poor people live without fundamental freedoms of action and choice that the better-off of in society take for granted. They often lack adequate food and shelter, education and health, deprivations that keep them from leading valued life. They are often exposed to ill treatment by society and individuals and are powerless to influence key decisions affecting their lives. Poverty is pronounced deprivation in well-being. To be poor is to be hungry, to lack shelter and clothing, to be sick and not cared for, to be illiterate and not schooled (World Bank, 1997). Poor people are particularly vulnerable to adverse events outside their control. They are often treated badly by institutions of state, society and excluded from voice and power in these institutions. This is confirmed by Abdullahi (1996) when discussing poverty alleviation in Ghana, Uganda, Zambia and Malawi.

Causes of poverty

The causes of poverty are complex and interrelated. The World Bank's Africa Region Poverty Task Force concluded that the basic causes of poverty are lack of access to services and opportunities and inadequate endowments specifically:

- inadequate access to employment opportunities,
- inadequate access to the means of supporting rural development in poor regions,
- inadequate access to markets for goods and services that the poor can sell, low endowment of human capital as a result of inadequate access to education, destruction of natural resource endowments,
- inadequate access to assistance for those living at the margin and those victimised by transitory poverty,
- inadequate participation of the poor in design of development programmes.

The large number of people in poverty implies an inefficient use of resources and increases the risks of social upheaval. Large population makes the situation more complex. Poor education and large illiterate population is a serious major contributing factor to poverty.

Home Economics Education and Career Opportunities

The definition adopted by the Ghana Home Economics Association in Axim was "an applied science concerned with the development and effective use of human and material resources and community for a better quality of life" (Nsarkoh, 1976). Fleck (1980) posits that the focus of Home Economics is family in its various forms. Home Economics is a field of knowledge and services primarily concerned with strengthening the family life through educating the individuals and families and the means to satisfying these needs. Olaitan and Agusiobo (1981) also defined Home Economics as the study of all the elements of family living and everything that involves or relates to the welfare of the family members. It is a field of study that provides the necessary knowledge for guiding human beings towards a more self-rewarding and fulfilled life, within the context of home management and family life. The American Home Economic Association says Home Economics is a "field of knowledge and service concerned primarily with strengthening family life (East, 1980).

From the above definitions, one can conclude that home economics education should be the blue print for life and every human being must have home economics education to go through life confidently. Anyakoha (2001) confirms this idea by saying that home economics helps with the development, use and management of human and material, resources, for the greater welfare of individuals, families and human society in its entity. It strives to solve the most pressing problems that challenge the families now as well as emerging ones. These problems include poverty. Global unemployment and constant retrenchment in Ghana has made it clear to every Ghanaian to strive for a more reliable and independent mode of survival. This can be achieved if one is basically equipped with the relevant knowledge and practical skills. Home Economics is a skill oriented subject which is capable of equipping the graduates with knowledge and skills which will enable them be self-employed and contribute effectively to the socio economic development of the individual, the family and the society (Uzoezie, 1990).

In Ghana, the objectives of the home economics programme for senior secondary schools, according to the syllabus, are to:

1. equip the individual to develop skills that will enable him/her improve the quality of life.
2. understand the factors in the family, community and society which help in meeting basic needs
3. recognise the importance of good consumer skills in all areas of life.
4. apply management skills in all aspects of living.
5. appreciate the need for healthy living through improved sanitation and environment.
6. develop skills that will equip students for independent living.
7. to acquire knowledge and develop marketable skills which can be used in later life (Ministry of Education, 1986:iii).

Home economics aims at providing marketable skills. This is in line with the general aims of the new education reforms. Home economics education should be able to contribute to manpower development by equipping individuals with occupational skills to make them self-reliant. This is confirmed by Anyakoha, (1988) that Home economics occupations abound and that Home Economics is capable of preparing youths and adults for entry into various Home Economics occupations. Some of the career opportunities in Home Economics include: teaching, home economists in businesses such as catering, sewing, interior decorating, dietetics, research, child caring, running a laundry, etc.

Apart from the above listed careers, Home Economics education helps the individual to improve the quality of his/her life which improves self worth or self esteem. The programme helps one to understand factors in the family, community and society which help in meeting basic needs. It makes people more responsible and provides good consumer skills in all areas of life. It empowers consumers to be more assertive in the market place so that they get their money's worth. They buy good quality goods which will last longer. They do not buy on impulse and thus save money. They plan and budget to live within their income and thereby stretch their income.

Home Economics education also provides management skills in living and help people to appreciate the need for healthy living through improved sanitation and environment. When the family is healthy, they can work harder. At the same time they do not spend money on medical bills. The course teaches knowledge in planning and preparing healthy nutritious meals which help develop the brain and maintain healthy bodies. The benefits of Home Economics education cannot be over emphasized in the eradication of poverty both in the family and in the nation.

Some ways in which home economics education can help provide employment to reduce poverty are:

i. *Caterer* - operate a restaurant or cater for functions, operate a bakery.
ii. *Sewing* - establish a sewing school to train others and open a boutique to sell garments and sew custom made garments.
iii. *Child Care* - can operate a crèche or day care centres to earn a living
iv. One can be an interior decorator
v. Plant and sell vegetables and flowers
vi. One can open a laundry or collect and wash and iron people's clothes for a living.
vii. One can crochet articles for sale
viii. One can be a demonstrator in the shops for a living.
ix. One can produce crafts for sale.

Summary and Recommendations

Home Economics is a skill oriented subject that equips individual with marketable skills. It also equips students with consumer and management

skill. All these help to make individuals save money, become self employed and manage better the available resources as well as prevent diseases and poverty. Based on the discussion above, the following recommendations are made:

1. Government should involve Home Economists in the planning and implementation of any poverty alleviation programme.
2. Home Economists should use their professional skills to teach women folks especially the unemployed
3. Home Economists extension workers should evolve special poverty alleviation initiatives for women groups based on their environmental needs.
4. Home Economists should counsel families and organise talks to help the rural poor improve their resource management skills and their lives.
5. The home economic association should come out more to adopt some villages and help the women folk and children.
6. Home Economics education is very vital for living so all students should be made to study Home Economics to senior secondary level to prepare them for life.

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Effects of Television and Programmed Instruction on the Achievement of Hearing Impaired in Mathematics

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Abstract

This study was conducted to find out the comparative effects of television and programmed instruction on the achievement of the hearing impaired in mathematics. A total of 30 JSS students from Cape Coast School for the Deaf were used for the study. The research design was the pre-test – post test control group design. Results indicated that the hearing impaired who were treated to television and programmed instruction had significantly higher gain scores than those treated to traditional teaching techniques. Implications for the Ghana Teaching Service are given.

Introduction

Mathematics forms the bedrock on which human development hinges. It permeates all human activity be it in the sciences, art or business. Furthermore mathematics is a subject which develops human intellect because almost every human activity involves one form of calculation or another, not least, the hearing impaired (Jones 1997). In an experimental study conducted by Thekaray (1979:21), it was found that a quarter of the hearing impaired came out among the first twenty best students who took a mathematics test in a high school in California. The sample consisted of a hundred students comprising fifty hearing impaired and fifty from mainstream classes. In his conclusion, Thekaray asserted that apart from the malfunctioning auditory organs of the hearing impaired, their intellectual capabilities are similar to those of other people except that most societies do not pay adequate attention to their education and socio-economic development. He then recommended that all amenities and facilities provided for mainstream students should also be made accessible to the hearing impaired in addition to the special hearing aids and other equipment they needed.

Programmed instruction is a controlled, carefully specified and skillfully arranged learning experience which is self-instructional and self-corrective (Dale, 1969). Educational Television is the use of non-commercial television programmes for classroom teaching.

Method

Sample

The Ghana government, through the Ghana Education Service has established many special schools in the country. To date, there are thirteen schools for the deaf in Ghana. This means that every region has one school for the deaf, except

the Eastern Region which alone has three of such special schools. It was from the school of the Deaf in Cape Coast that the sample for this study was taken. A total of 30 junior secondary school students were randomly assigned to two experimental and one control group.

Hypothesis

The null hypothesis for this study is:

HO_1 There will be no significant difference in the mean achievement scores of the hearing impaired JSS students who are taught mathematics with television, programmed instruction and traditional method.

Procedure

Before the study commenced, the researcher travelled to the school and collected the mathematics syllabus and other vital information needed for the study from the headmaster. She then used the technical staff and electronic equipment in the Educational Resource Centre of the University College of Education of Winneba to produce the televised instruction which was recorded in a videotape.

The programmed instruction was also developed in line with the content of the chosen topic of the mathematics syllabus. On the day the study was to be conducted, all the necessary technical staff including the video cassette, a large television monitor, fifty copies of the programme instruction, the validated test items and supplementary teaching aids were transported to Cape Coast for the study.

Experimental Design

The experimental design was the pretest-posttest control group design (Campbell and Stanley 1966) Campbell and Stanley gave extensive explanations of how this type of design helps to control extraneous variables, maturation and testing. The students were randomly assigned into experimental and control groups.

Treatments

The two experimental groups consisted of 10 students who were exposed to televised instruction (TV) and the other 10 students who were exposed to programmed instruction (PI). The control group consisted of 10 students who were exposed to the normal conventional teaching method. Except for the differences in the medium of instruction use for each group, the content and topic of the mathematics instruction were the same for all the groups. The topic of the mathematics instruction is “types of angles”. A discussion between the researcher the mathematics teacher and the Headmaster assured the researcher that this selected topic has never been taught to the students used for the study. In both the experimental and control groups the normal mathematics teachers were used to deliver the mathematics instructions. The same test items were used for both the pretest before the mathematics instructions and also as post-tests after the instructions.

Results

The pretest and posttest scores for the experimental and control groups were computed to get the means and standard deviation. A two – tailed t-test was used to detect if there was any significant difference between the pretest and post test mean scores of the experimental and control groups. A one – way analysis of variance was used to test and compare the three posttest scores of the experimental and control groups to detect if the differences were significant at the .05 probability level. Results are displayed on Table 1 and 2.

Table 1 **Mean, standard deviation and t-test results of the pretest and post test scores of the control and experimental groups**

Group	Pretest N=30 Mean	Pretest N=30 Standard Deviation	Posttest N=30 Mean	Posttest N=30 Standard Deviation	t-value
Control	8.33	2.50	11.72	4.57	2.25
TV (Experimental)	9.76	3.22	26.80	5.80	6.72
P.I (Experimental)	8.54	2.33	25.33	4.73	7.49

Table I shows the mean and standard deviations for he pretest and posttest mean scores for the experimental and control groups. The t-test results indicate that the gain scores of both experimental groups were significant and superior to that of the control groups which was not significant at the 0.05 level. In order to find out if there was any significant difference among the three groups a one-way analysis of variance (ANOVA) was used to compare them. The details are displayed on table 2.

Table 2 Summary of Analysis of Variance

Source	Sum of squares	Df.	Mean square	F.
Between groups	19.14	49	1.03	4.80
Within groups	36.28	124	.44	

The results on the table shows that the variation of scores under the sum of squares is higher within the groups than between them. This implies that the differences in the mean scores which exist between each of the three groups simultaneously is higher than that which exist between any two of the groups taken each at a time. The F-ratio of 4.80, which is an expression of the variation within the test means, indicates that it is significant and not by chance.

Discussion

Results of this study show that the null hypothesis has been rejected at the 0.05 level of significance. The differences in the instructional media to which the different groups were treated gave rise to an exponential increase in their posttest gain scores. The gain scores of the two experimental groups were

superior to those of the control group. This result once again, is an index to the fact that traditional techniques of instruction is becoming obsolete in the fast changing society of Ghana.

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The Influence of Native Language on Ghanaian Junior Secondary School Students' Understanding of some Science Concepts

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Abstract

The purpose of the study was to investigate the effect of the native language, location of the school, and the educational level of Junior Secondary School (JSS) students on the meanings they give to science Junior Secondary School (JSS words when used in and out of science context.. Two multiple choice tests involving twenty-five common words in science were administered to 1028 students (573 males and 455 females) from twelve Junior Secondary Schools (6 urban and 6 rural) in Northern Ghana. The tests first sought to find out the extent to which the students' understand the science concepts and secondly to find out how their native language influenced this understanding. The general performance of the students was very low. They performed better on 'science concepts with native language equivalent words' than those without 'native language equivalent words' with mean scores of 26.1% and 30.8% respectively. In this light, the paper argues that the native language of the learner has an influence on the students' understanding of science concepts and that the native language of the student can not be ignored during science instruction. There is therefore the need to develop language register for science instruction.

Introduction

Language is one of the various media through which every culture expresses its concepts about the environment. It is a vehicle for the expressions of thoughts from which the concepts concerning the environment are formed by the individual. In science teaching, these functions of language can only be effective if common meanings are given to the words encountered during the teaching/learning process and in scientific texts. This situation can be facilitated if the language of instruction is the first language of the learner (Mori et. al., 1976) and the words used are understood in the context in which they are used (Bently and Watts, 1992).

Learning science through a second language may pose a number of problems. Every culture has its unique language through which the individual's perceptions of the world are expressed (Alexander, 1967). Therefore words used during instruction in science may have different cultural roots from those of the native language of the learner. In science education, certain words needed to explain certain natural phenomena or to understand some science concepts may or may not be available when a foreign language is the medium of instruction. For example, a study conducted by Yakubu (1976) to identify equivalent words in Kusaal language for such concepts as: temperature, energy and speed in parts of Northern Ghana showed that they were non existent.

Among the Kpelle of Liberia, Gay and Cole (1967) found that though they measured time and volume, their culture lacked measurements of weight, area and time. The learning of

these words without local equivalents proved difficult for the students. In another study carried out by Mori and Kitagawa (1974) to find out the role of native language on children's formation of the concept of speed by Japanese and Thai children, it was found that the Thai language accelerated the Thai children's acquisition of the concept of speed while the Japanese language impeded the Japanese children's development of the concept. Therefore the native language of the child can facilitate or hinder the child's understanding of science (concept) words.

Collison (1974) carried out a study to compare the native language and English language as medium of instruction for concept acquisition among Ghanaian children. The study revealed consistently that where English was the language of instruction, majority of the experimental subjects were not able to exercise their conceptual potential. The native languages proved more fruitful for enhancing the class interaction of the children.

Tobin and Mcrobbie (1996) investigated the significance of limited English proficiency (LEP) to performance in science of Chinese-Australian students. The investigation revealed that despite the students' effort to learn chemistry, difficulties in speaking and writing English were factors that limited their performance. The study also supported the assertion that learning chemistry could be facilitated when LEP students were provided with opportunities to fully employ their native language tools. Also Tobin and Crobbie (1996) showed that science achievement of limited English proficiency (LEP) students in grade 10 was statistically lower than that of students who were proficient in English in all the content areas assessed.

Benz (1996) followed eleven non-English speaking students as they adapted to community college content courses taught in English. The non-English students were examined in three areas including requirement for content classes. The study revealed that the students drew on their native language education as they coped with the demands of the content classes. The native language is therefore an important factor which cannot be ignored in science concept formation.

Literacy plays an important role in determining school-aged children's academic achievement (Garcia, Ku and Reyes, 2001). The ability to read and write in one language may not be easily acquired for young users because it involves mastering skills that are specific to the written language. The task is even more challenging for second language learners. For students whose native language is not English, the process of literacy development in English can be particularly difficult if they did not bring to the learning process a foundation of literacy in their own language. The development of literacy in student's native language provides the social, cognitive, and linguistic foundation for academic success (Garcia, Ku and Reyes, 2001). It is through their first languages and home cultures, that students create frameworks from new understanding. Learning the language of science starts prior to formal education. Communication skills start before academic skills. Thus family communication appears to be of importance in developing the academic skills of the learner and the family's patterns can affect the development of a child's science literacy skills as well.

In Ghana, as a national policy, the native language is used as the medium of instruction during the first 3 years of primary schooling; thereafter, English language is used as the medium of instruction. The effect of this switch to English language, on the acquisition of

science concepts has not been investigated at the JSS level. It is therefore desirable to study the meanings Ghanaians JSS students give to science concepts words when used out of and in science context and whether the native language of the student has any influence on the interpretation she/he gives to the words out of, and, in, science context.

Method

Sample

The study involved 1028 students (573 male and 455 females) from 12 junior secondary schools (6 in rural areas: 247 males, 162 females; 6 in urban areas: 362 males, 293 females) in Navrongo District of Upper East Region of Ghana. Whole classes of forms 1 to 3 were used. The average age of the students was 14 years. The principal native languages spoken in the area are Nakani, Buli, and Kassem. However Kassem is predominantly spoken and it is the official native language studied as a subject in the junior secondary schools.

In the rural areas agricultural activities are the predominant occupation of the adult population. Those in the urban areas are either government employees or small scale business men and women. Majority of the urban population is literate while the reverse is the case for the rural areas. The language environments of the schools investigated were different. Though the schools were poorly staffed, the rural schools were worse off than the urban schools. In most cases there were only three teachers handling all subjects in the school. Some of the schools had more than a class in a form. The contact hours between the English language teachers and the students were quite reduced because of the staffing of the schools. Moreover majority of the teachers handling the English language classes were teachers with Diploma certificate in Ghanaian Languages.

The highest qualification of the teachers was a Diploma certificate in Ghanaian Language. Majority of the teachers were 3-year post-Secondary Certificate 'A' Teachers. Those handling the science courses did general courses in Agricultural science or General Science. Some of the rural schools investigated had no qualified Science and English Language teachers. It was common to find untrained ordinary level holders and senior secondary school certificate holders teaching English language classes.

Despite the efforts by the Ghana Government to supply each basic school student at each level with a copy of the recommended English readers and a textbook for each other subject, the ratio was still two students to a reader and a textbook for each other subject. Also the students were not allowed free access to the books. They were allowed to use them only during English language lessons. This further decreased the contact hours between the students and the readers.

Instrumentation

The instrument used for the study consisted of two multiple choice tests (Test A and Test B) involving twenty-five science words. The words are encountered by the students in their daily use of English language, and are used in radio and television broadcasts. They are also found in the textbooks used at the three levels of the junior secondary school.

Test A, which was administered first, required the students to select from four options numbered A-D the word similar in meaning to the word being tested which was not used in any specific context.

E.g. *Rate* can mean

A. Shape

B. Size

C. Speed

D. Distance

Test B, which was administered immediately after test A, involved the same words but each was used in specific science context. For each item, the subjects were also expected to choose from four options numbered A-D the one that best explained the word tested in the science context.

E.g. The experiment is designed to study the *rate* of evaporation. This means it is designed to study:

A. What happened during evaporation?

B. how quickly evaporation takes place

C. what is left after evaporation

D. why evaporation takes place

The content validity of the instrument was determined by four senior science educators in the University of Cape Coast. They individually confirmed the fact that the words as used in the instrument are among words in common usage in the science textbooks for JSS students in Ghana. Since the instrument was modified to suit the cultural context of the students of the study area, a pilot study was carried out to determine the reliability of the instrument. The KR-20 formula was used to establish the internal consistency of the instrument. The reliability coefficients were 0.85 and 0.80 for test A and B respectively, which were found adequate for the study.

Results and Discussion

The frequency distribution of the students' scores on the interpretation of science words when used out of (test A) and in science context (test B) are presented in Table 1.

Table 1 JSS students' number and percentage of correct responses to test items.

Science concept word tested	Correct Responses when used out of science context (Test A) Number of students (N = 1028)	Percentage correct Responses	Correct Responses when used in science context (Test B) Number of students (N = 1028)	Percentage correct Responses
Average	305	29.7	321	31.2
Disperse	266	25.9	432	42.0
Displace	422	41.1	339	33.0
Conserve	372	36.2	368	35.8
Contaminate	310	30.2	338	32.9
Effect	171	16.6	265	25.8
Essential	411	40.0	419	40.8
Estimate	214	20.8	270	26.3
Convert	256	24.9	293	28.5
Rate	209	20.3	289	28.1
Source	372	36.2	335	32.6
Prepare	534	51.9	307	29.9
Separate	485	47.2	366	35.6
Surround	272	26.5	247	24.0
Dehydrated	199	19.4	249	24.2
Function	256	24.9	382	37.2
Proportion	197	19.2	276	26.8
System	353	34.3	399	38.8
Generate	222	21.6	434	42.2
Device	358	34.8	229	22.3
Crude	230	22.4	402	39.1
Efficient	186	18.1	380	37.0
Independent	596	58.0	285	27.7
Absorb	124	27.9	278	27.0
Constant	205	19.9	219	21.3

N is the total number of students who participated in the study

The performance of the students in both tests was generally very poor. Less than half of the students (1028) gave correct interpretations to the science words in both tests except the words "independent" and "prepare" in test A where 596 (58%) and 534 (51.9%) of the students gave correct interpretations to the words respectively (Table1). The mean scores of the tests (A and B) were 6.53 and 7.68 (i.e. *26.1% and 30.8%*) respectively. The students seemed to have performed better in test B. Despite the general poor performance on the tests, there was a significant difference ($t = 4.05$, $df = 1026$, $p < 0.001$) between the student mean scores in test A and B. The students performed better in test B (mean = 7.68) than in test A (mean = 6.53). The general trend was an increase in the frequency scores for corresponding test items in test B, except in few instances involving "displace", "conserve", "source", "prepare", "device" and "independent" (Table 1). The improvement in the test scores may be due to the context based nature of test B where the words were used in science context. The context might have made the meanings of the words clearer except those indicated above.

The poor performance of the students in test A may be due to a number of factors such as poor vocabulary and word association, the general poor standard in English language among Ghanaian pupils at the basic school level (Sandman, 1993; Kraft, 1994). Poor

vocabulary and poor word association may hinder science concept formation since literacy plays an important role in determining students' academic performance (Garcia, Ku and Reyes, 2001).

Some of the words have equivalent words in Kassem, the official native language of the students. Tables 2 and 3 show some of the words tested which have native language equivalent words and words tested without native language equivalent words respectively.

Table 2 Students' performance on concepts with native language equivalents

		% Correct Interpretation	
Science Concept Tested	**Native language equivalent of concept**	**Test A**	**Test B**
Disperse	'jage' (scatter)	25.6	42.0
Prepare	'ke' (make)	51.9	29.9
Conserve	'che/'gere' (save)	36.2	35.8
Surround	'gelimi' (encircle)	26.5	24.0
Function	'tonga' (work)	24.9	37.2
Convert	'lere' (change)	24.9	28.5
Estimate	'mange' (measure)	20.8	26.3
Displace	'le' (remove)	41.1	33.0
Average	'mange' (measure)	29.7	31.2
Separate	'Iwe' (pick)	47.2	35.6
Absorb	'ngu' (drink/soak)	27.9	27.0
	Average % Correct	32.4	31.9

Table 2 Students' performance on concepts with native language equivalents

		% Correct Interpretation	
Science Concept Tested	**Native language equivalent of concept**	**Test A**	**Test B**
Efficient		18.1	37.0
Contaminate		30.2	32.9
Effect		16.6	25.8
Essential		40.0	40.8
Rate		20.3	28.1
Source		36.2	32.6
Dehydrate		19.4	24.2
Proportion		19.2	26.2
System		34.3	22.3
Generate		21.6	42.2
Device		34.8	22.3
Crude		22.4	39.1
Independent		58.0	27.7
Constant		19.9	21.3
Average		27.9	30.2

The students performed poorly on science words with native language equivalents in both tests (Tables 2 & 3). Less than 50% gave correct interpretations to these words except for 'prepare' in test A where 51.9% of the students gave correct interpretations (Table 2). Also the native equivalent for convert is "lere" but only 24.9% and 28.5% of he students gave correct interpretation to the word in test A and B respectively. Similarly, 26.5% and 24% of the students gave correct interpretation to the word “surround” with native equivalent "gelimi" in test A and B respectively. Perhaps there is no congruence between the science language meanings and those of their corresponding native equivalents. The meanings may be similar but not the same and the differences might have contributed significantly to the students’ poor performance. The cultural experiences of the students with the native equivalent words might have influenced the meanings they gave to their corresponding science concept words.

Though the performance of the students on some of the science concept words without native equivalents (Table 3) was generally poor, their performance on some of these words in both tests (Tables 2 & 3) was better than their performance on some science words with native language equivalents (Table 2). The percentage scores of the students on some of the science concept words without native equivalents (Table 3) were higher than those of some of the science concept words in Table 2 with native equivalents. The students' performance on some of these words in both tests is given below:

Dehydrate: 19.4% in test A and 24.2% in test B

Contaminate: 30.2% in test A and 32.9% in test B

Essential: 40% in test A and 40.8% in test B

Perhaps the better performance on such words may be due to the fact that the meanings of these words are not clouded by the cultural experiences of the students related to some of the native equivalent words. This seems to differ with some findings reported in the literature (Gay and Cole, 1967; Mori et. al., 1976; Yakubu, 1976; Tull, 1991) that non-equivalence between science concepts or science words in textbooks and native language of students can hinder the understanding of such words and hence affect their acquisition of science concepts. Therefore factors other than the presence or absence of native language of the learner, where instructions is in a foreign language, may affect the learner's understanding of science concept words. These factors include dissimilarity between the English meaning of the science word and its native language equivalent, and the interference of the cultural context meaning of the word. For example the equivalent word for estimate is 'mange' which means 'measure', for 'absorb' is 'ngu'. 'Ngu' has two English meanings depending on the context in which it is used and these are ‘drink’ and ‘soak’ (Table 2). The low score the students obtained in items involving estimate and absorb may be attributed to this lack of congruence between their English meanings and those of their corresponding native equivalents. For example most of the students interpreted estimates as 'careful measure' instead of 'careful guess' in both tests.

Fifty-eight percent of the students correctly interpreted 'independent' when used out of science context but this figure dropped to 28% (Table 3) when it was used in science context. The correct option for independent in test A was 'free'. The drastic drop in the students’ correct responses to the word in test B may be attributed to their failure to get its contextual meaning. The commonest response among the students was … 'as the baby

grows it needs more attention from the mother.' The students' responses seem to reflect their cultural experiences with growing babies. A toddler needs more attention as it gains mobility to prevent it from getting into trouble such as falling over an edge, etc. The students' experience as baby sitters to other siblings in the family might have influenced their interpretations of the word. This seems to confirm the findings of (Mori, et. al., 1976; Tull, 1991) that where the learner fails to get the context of a word in science text she/he tends to interpret it from the perspective of his/her cultural environmental experience.

Implications and Recommendations

The poor performance of JSS students on science concept words in the tests may be due to poor standard of English language among basic school students. Similar studies (Sandman, 1993; Kraft, 1994) on the level of proficiency in English language of Ghanaian pupils at basic schools (Primary and JSS), reported that poor vocabulary and poor word association affected their proficiency in English language. A number of factors may account for this. The contact time of the students with English language is limited to the classroom. Very little English language is spoken at home since most adult Ghanaians are illiterate and this number is higher in the rural areas (World Bank Report, 1993).

Also there is a limited variety of English readers in the schools. In recent past teachers used to copy passages from readers on the chalkboard for the pupils to read. This affected the reading habits of the students with consequential effects on word vocabulary and comprehension of text. Despite the Government's effort to ensure that the ratio of English readers and textbooks on other subjects to students is one to one the ratio is still two to one and in some cases it is three to one.

Also oral spelling of words and written dictation of English words are no longer emphasised in the schools. This may lead to poor vocabulary which affect the meaning students give to science words encountered in science text and in everyday use of the English language. Science and language teachers should engage students in oral word spelling, dictation and word association exercises to improve the students' vocabulary. The word connections from these exercises will improve their comprehension of science words when encountered in science texts.

The ability to understand and explain in clear language the meanings of fundamental science concepts is central to science literacy. The inability to interpret correctly science concept words encountered in science textbooks and in every day use of the English language hinders students' understanding of science concepts and impedes science instruction.

Inadequate supply of recommended texts and other reading materials are common features in most developing countries where English is a second language. Therefore supply of adequate texts and other reading materials that could enhance students' conceptualisation of science words should be given the priority it deserves.

In countries where the medium of instruction for the first three years of schooling is in the local language, the headteachers should enforce the use of English language as medium of communication within the school premises to increase the contact time of students with the language.

Studies by Mori et al (1976) and Yakubu (1976) reported that where native equivalents to science words exist the students are able to understand the latter. This was not so in this study. Their studies were conducted in elementary schools where the native language was the official language of communication for the greater part of the programme. Though the native language is officially recommended for the first three years of elementary school instruction in most cases, it is used for the greater part of the elementary school because of the poor acquisition of English words by the pupils. They are therefore amenable to native words than English ones. Hence their better performance in some science words with native language equivalents is not unexpected.

At the JSS level the recommended medium of instruction is English language, perhaps this practice is responsible for the JSS better performance in science words without native language equivalents. Also some of these words are encountered frequently by students in everyday use of English language and in science text. For example, the word “essential" in essential commodities”, is household terms in Ghana and for ‘independent’, Ghanaian students in basic schools celebrate Independence Day annually.

The poor performance on science words with native equivalents could be attributed to the early switch from the native language of the students to English language as medium of instruction in Ghanaian schools. The switch is effected after the first three years of basic school education. Collison (1974) compared the native language(s) (of Ghanaian pupils) and English language to find out which of these was a better medium of instruction. The native languages were better media for instruction of pupils at the basic level. He recommended a long period of instruction of pupils in their native languages at the basic school for better conceptual development because high linguistic and cognitive development in the child can lead to transfer of linguistic skills to a second language (Kraft, 1994).

The findings of this study suggest the use of the native language along side English language in science instruction for proper language development and effective transfer to the second language after the elementary. Also when students begin to use the second language exclusively for learning then the native language should be discontinued for any reason whatsoever to avoid confusion.

Ghana, like other countries where English language is studied as a second language, the true position is that English might really be the third or fourth language. In most cases it is the language of the majority tribe that becomes the official local language in schools (Ghana, Nigeria, Sierra Leone among other countries). For example in this study the major native languages spoken are Nankani, Buli and Kassem but Kassem is the official language used in schools. It means that those who speak Nankani and Buli have first to learn Kassem as second language and English as a third language. The impact of this practice on students’ performance in science needs to be investigated.

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The Influence of Native Language on Ghanaian Junior Secondary School Students' Understanding of some Science Concepts

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Abstract

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H. Distance

Test B, which was administered immediately after test A, involved the same words but each was used in specific science context. For each item, the subjects were also expected to choose from four options numbered A-D the one that best explained the word tested in the science context.

E.g. The experiment is designed to study the *rate* of evaporation. This means it is designed to study:

E. What happened during evaporation?

F. how quickly evaporation takes place

G. what is left after evaporation

H. why evaporation takes place

The content validity of the instrument was determined by four senior science educators in the University of Cape Coast. They individually confirmed the fact that the words as used in the instrument are among words in common usage in the science textbooks for JSS students in Ghana. Since the instrument was modified to suit the cultural context of the students of the study area, a pilot study was carried out to determine the reliability of the instrument. The KR-20 formula was used to establish the internal consistency of the instrument. The reliability coefficients were 0.85 and 0.80 for test A and B respectively, which were found adequate for the study.

Results and Discussion

The frequency distribution of the students' scores on the interpretation of science words when used out of (test A) and in science context (test B) are presented in Table 1.

Table 1 JSS students' number and percentage of correct responses to test items.

Science concept word tested	Correct Responses when used out of science context (Test A) Number of students (N = 1028)	Percentage correct Responses	Correct Responses when used in science context (Test B) Number of students (N = 1028)	Percentage correct Responses
Average	305	29.7	321	31.2
Disperse	266	25.9	432	42.0
Displace	422	41.1	339	33.0
Conserve	372	36.2	368	35.8
Contaminate	310	30.2	338	32.9
Effect	171	16.6	265	25.8
Essential	411	40.0	419	40.8
Estimate	214	20.8	270	26.3
Convert	256	24.9	293	28.5
Rate	209	20.3	289	28.1
Source	372	36.2	335	32.6
Prepare	534	51.9	307	29.9
Separate	485	47.2	366	35.6
Surround	272	26.5	247	24.0
Dehydrated	199	19.4	249	24.2
Function	256	24.9	382	37.2
Proportion	197	19.2	276	26.8
System	353	34.3	399	38.8
Generate	222	21.6	434	42.2
Device	358	34.8	229	22.3
Crude	230	22.4	402	39.1
Efficient	186	18.1	380	37.0
Independent	596	58.0	285	27.7
Absorb	124	27.9	278	27.0
Constant	205	19.9	219	21.3

N is the total number of students who participated in the study

The performance of the students in both tests was generally very poor. Less than half of the students (1028) gave correct interpretations to the science words in both tests except the words "independent" and "prepare" in test A where 596 (58%) and 534 (51.9%) of the students gave correct interpretations to the words respectively (Table1). The mean scores of the tests (A and B) were 6.53 and 7.68 (i.e. *26.1% and 30.8%*) respectively. The students seemed to have performed better in test B. Despite the general poor performance on the tests, there was a significant difference ($t = 4.05$, $df = 1026$, $p < 0.001$) between the student mean scores in test A and B. The students performed better in test B (mean = 7.68) than in test A (mean = 6.53). The general trend was an increase in the frequency scores for corresponding test items in test B, except in few instances involving "displace", "conserve", "source", "prepare", "device" and "independent" (Table 1). The improvement in the test scores may be due to the context based nature of test B where the words were used in science context. The context might have made the meanings of the words clearer except those indicated above.

The poor performance of the students in test A may be due to a number of factors such as poor vocabulary and word association, the general poor standard in English language among Ghanaian pupils at the basic school level (Sandman, 1993; Kraft, 1994). Poor

vocabulary and poor word association may hinder science concept formation since literacy plays an important role in determining students' academic performance (Garcia, Ku and Reyes, 2001).

Some of the words have equivalent words in Kassem, the official native language of the students. Tables 2 and 3 show some of the words tested which have native language equivalent words and words tested without native language equivalent words respectively.

Table 2 **Students' performance on concepts with native language equivalents**

		% Correct Interpretation	
Science Concept Tested	**Native language equivalent of concept**	**Test A**	**Test B**
Disperse	'jage' (scatter)	25.6	42.0
Prepare	'ke' (make)	51.9	29.9
Conserve	'che/'gere' (save)	36.2	35.8
Surround	'gelimi' (encircle)	26.5	24.0
Function	'tonga' (work)	24.9	37.2
Convert	'lere' (change)	24.9	28.5
Estimate	'mange' (measure)	20.8	26.3
Displace	'le' (remove)	41.1	33.0
Average	'mange' (measure)	29.7	31.2
Separate	'Iwe' (pick)	47.2	35.6
Absorb	'ngu' (drink/soak)	27.9	27.0
	Average % Correct	32.4	31.9

Table 2 **Students' performance on concepts with native language equivalents**

		% Correct Interpretation	
Science Concept Tested	**Native language equivalent of concept**	**Test A**	**Test B**
Efficient		18.1	37.0
Contaminate		30.2	32.9
Effect		16.6	25.8
Essential		40.0	40.8
Rate		20.3	28.1
Source		36.2	32.6
Dehydrate		19.4	24.2
Proportion		19.2	26.2
System		34.3	22.3
Generate		21.6	42.2
Device		34.8	22.3
Crude		22.4	39.1
Independent		58.0	27.7
Constant		19.9	21.3
Average		27.9	30.2

The students performed poorly on science words with native language equivalents in both tests (Tables 2 & 3). Less than 50% gave correct interpretations to these words except for 'prepare' in test A where 51.9% of the students gave correct interpretations (Table 2). Also the native equivalent for convert is "lere" but only 24.9% and 28.5% of he students gave correct interpretation to the word in test A and B respectively. Similarly, 26.5% and 24% of the students gave correct interpretation to the word “surround” with native equivalent "gelimi" in test A and B respectively. Perhaps there is no congruence between the science language meanings and those of their corresponding native equivalents. The meanings may be similar but not the same and the differences might have contributed significantly to the students’ poor performance. The cultural experiences of the students with the native equivalent words might have influenced the meanings they gave to their corresponding science concept words.

Though the performance of the students on some of the science concept words without native equivalents (Table 3) was generally poor, their performance on some of these words in both tests (Tables 2 & 3) was better than their performance on some science words with native language equivalents (Table 2). The percentage scores of the students on some of the science concept words without native equivalents (Table 3) were higher than those of some of the science concept words in Table 2 with native equivalents. The students' performance on some of these words in both tests is given below:

Dehydrate: 19.4% in test A and 24.2% in test B

Contaminate: 30.2% in test A and 32.9% in test B

Essential: 40% in test A and 40.8% in test B

Perhaps the better performance on such words may be due to the fact that the meanings of these words are not clouded by the cultural experiences of the students related to some of the native equivalent words. This seems to differ with some findings reported in the literature (Gay and Cole, 1967; Mori et. al., 1976; Yakubu, 1976; Tull, 1991) that non-equivalence between science concepts or science words in textbooks and native language of students can hinder the understanding of such words and hence affect their acquisition of science concepts. Therefore factors other than the presence or absence of native language of the learner, where instructions is in a foreign language, may affect the learner's understanding of science concept words. These factors include dissimilarity between the English meaning of the science word and its native language equivalent, and the interference of the cultural context meaning of the word. For example the equivalent word for estimate is 'mange' which means 'measure', for 'absorb' is 'ngu'. 'Ngu' has two English meanings depending on the context in which it is used and these are ‘drink’ and ‘soak’ (Table 2). The low score the students obtained in items involving estimate and absorb may be attributed to this lack of congruence between their English meanings and those of their corresponding native equivalents. For example most of the students interpreted estimates as 'careful measure' instead of 'careful guess' in both tests.

Fifty-eight percent of the students correctly interpreted 'independent' when used out of science context but this figure dropped to 28% (Table 3) when it was used in science context. The correct option for independent in test A was 'free'. The drastic drop in the students’ correct responses to the word in test B may be attributed to their failure to get its contextual meaning. The commonest response among the students was … 'as the baby

grows it needs more attention from the mother.' The students' responses seem to reflect their cultural experiences with growing babies. A toddler needs more attention as it gains mobility to prevent it from getting into trouble such as falling over an edge, etc. The students' experience as baby sitters to other siblings in the family might have influenced their interpretations of the word. This seems to confirm the findings of (Mori, et. al., 1976; Tull, 1991) that where the learner fails to get the context of a word in science text she/he tends to interpret it from the perspective of his/her cultural environmental experience.

Implications and Recommendations

The poor performance of JSS students on science concept words in the tests may be due to poor standard of English language among basic school students. Similar studies (Sandman, 1993; Kraft, 1994) on the level of proficiency in English language of Ghanaian pupils at basic schools (Primary and JSS), reported that poor vocabulary and poor word association affected their proficiency in English language. A number of factors may account for this. The contact time of the students with English language is limited to the classroom. Very little English language is spoken at home since most adult Ghanaians are illiterate and this number is higher in the rural areas (World Bank Report, 1993).

Also there is a limited variety of English readers in the schools. In recent past teachers used to copy passages from readers on the chalkboard for the pupils to read. This affected the reading habits of the students with consequential effects on word vocabulary and comprehension of text. Despite the Government’s effort to ensure that the ratio of English readers and textbooks on other subjects to students is one to one the ratio is still two to one and in some cases it is three to one.

Also oral spelling of words and written dictation of English words are no longer emphasised in the schools. This may lead to poor vocabulary which affect the meaning students give to science words encountered in science text and in everyday use of the English language. Science and language teachers should engage students in oral word spelling, dictation and word association exercises to improve the students’ vocabulary. The word connections from these exercises will improve their comprehension of science words when encountered in science texts.

The ability to understand and explain in clear language the meanings of fundamental science concepts is central to science literacy. The inability to interpret correctly science concept words encountered in science textbooks and in every day use of the English language hinders students’ understanding of science concepts and impedes science instruction.

Inadequate supply of recommended texts and other reading materials are common features in most developing countries where English is a second language. Therefore supply of adequate texts and other reading materials that could enhance students’ conceptualisation of science words should be given the priority it deserves.

In countries where the medium of instruction for the first three years of schooling is in the local language, the headteachers should enforce the use of English language as medium of communication within the school premises to increase the contact time of students with the language.

Studies by Mori et al (1976) and Yakubu (1976) reported that where native equivalents to science words exist the students are able to understand the latter. This was not so in this study. Their studies were conducted in elementary schools where the native language was the official language of communication for the greater part of the programme. Though the native language is officially recommended for the first three years of elementary school instruction in most cases, it is used for the greater part of the elementary school because of the poor acquisition of English words by the pupils. They are therefore amenable to native words than English ones. Hence their better performance in some science words with native language equivalents is not unexpected.

At the JSS level the recommended medium of instruction is English language, perhaps this practice is responsible for the JSS better performance in science words without native language equivalents. Also some of these words are encountered frequently by students in everyday use of English language and in science text. For example, the word "essential" in essential commodities", is household terms in Ghana and for 'independent', Ghanaian students in basic schools celebrate Independence Day annually.

The poor performance on science words with native equivalents could be attributed to the early switch from the native language of the students to English language as medium of instruction in Ghanaian schools. The switch is effected after the first three years of basic school education. Collison (1974) compared the native language(s) (of Ghanaian pupils) and English language to find out which of these was a better medium of instruction. The native languages were better media for instruction of pupils at the basic level. He recommended a long period of instruction of pupils in their native languages at the basic school for better conceptual development because high linguistic and cognitive development in the child can lead to transfer of linguistic skills to a second language (Kraft, 1994).

The findings of this study suggest the use of the native language along side English language in science instruction for proper language development and effective transfer to the second language after the elementary. Also when students begin to use the second language exclusively for learning then the native language should be discontinued for any reason whatsoever to avoid confusion.

Ghana, like other countries where English language is studied as a second language, the true position is that English might really be the third or fourth language. In most cases it is the language of the majority tribe that becomes the official local language in schools (Ghana, Nigeria, Sierra Leone among other countries). For example in this study the major native languages spoken are Nankani, Buli and Kassem but Kassem is the official language used in schools. It means that those who speak Nankani and Buli have first to learn Kassem as second language and English as a third language. The impact of this practice on students' performance in science needs to be investigated.

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Junior Secondary School Students' Ideas of Chemical Change

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Abstract

The study examined Junior Secondary School students' ideas about chemical change. The study also focused on the identification of misconceptions that students might harbour on this concept. It also sought to examine the implications of such ideas for teaching and learning of science at the basic level. Students selected for the study were from well-endowed and poorly-endowed schools in the Awutu-Effutu-Senya District in the Central Region of Ghana. In all 464 students were randomly sampled for the study. Data were collected within three weeks in 2003. Instruments used in the study consisted of a test and an interview schedule. The test was divided into two parts -A & B, consisting of 10 multiple choice items and one essay item respectively. The t-test statistic for independent sample was used to test the null hypothesis of the research question. The study found no significant differences between students from both well-endowed and poorly-endowed schools on the ideas they held about chemical change. Students from both sides show common misconceptions about chemical change. Such misconceptions include (i) that the burning of a candle is a physical change and (ii) the blackening of a glass rod is due to vapour from the flame. The interview revealed that junior secondary school students express themselves better orally than in written form when examined.

Introduction

Teachers can be astonished to learn that despite their best efforts, students do not grasp the fundamental ideas covered in class. Even some of the best students give right answers but are only using correctly memorised words. When questioned more closely, these students reveal their failure to understand fully the underlying concepts. Mazur (1996) reports that students in his physics class had memorised equations and problem-solving skills, but performed poorly on test of conceptual understanding.

The child even before he/she comes to school has certain ideas of the world as a result of his/her interaction with the environment. These are the child's preconceptions, which child relies on to explain any phenomena. Ignoring them during teaching leads the child to misconceptions of science concepts introduced to him/her formally. On the other hand if these preconceptions are considered and dealt with in class during formal science instructions children would be helped to form intuitive understanding of what concepts are learned. Concepts enable people to connect, explain and identify events and to predict what may happen next (Russell, 1956).

Russell (1956) states that the soundness of a child's concepts of things are the best measure of his probable success in school learning because meaning is fundamental to such success. In many cases, students have developed partially correct ideas that can be used as the foundation for further learning.

Children's conception of chemical change

Abraham, Williamson & Westbrook (1994) conducted research on children's conceptions of chemical change using a burning candle and a glass rod for their investigation. The rod was placed through the flame of the burning candle and a black film deposited on the rod. Children were asked to explain the source of the black film on the rod. They concluded that misconceptions concerning chemical change run through majority of the students. The most common misconception was that, burning of the candle was a physical change because the candle had undergone a phase change or was the same substance. Another major misconception reported was the notion that the black material from the rod came from the combustion of the wick. Four percent junior high school, 10% high school and 25% college students held this misconception. These students indicated that the wick was being burned, not the wax.

Other students focused on the rod and indicated that the burning of the candle was physical because the rod was unchanged or chemical because the rod was burned. Many thought the black film on the rod was due to a burning of the rod or some breakdown of the glass rod (Abraham *et al.,* 1994). Johnson (2000) reported on pupils' difficulties in explaining transformations that involve chemical reactions. Anderson (1990) described students' understanding of transformation of matter using five categories. Many researchers have used this categorisation of pupils' understanding. Krnel, Watson & Glazar (1998) said that students explain chemical reactions as modifications if they do not know the difference between the object and substance. Johnson (2000) thought the use of Anderson's categories favours pupils who have good conceptions. Johnson claimed that one could not see when a substance changes if one does not know what a substance is. Eskilsson (2003) in a study of 'student's ideas about chemical reactions' using interviews, concluded that young pupils in peer discussions developed new ways of explaining chemical reactions in a macroscopic level. Eskilsson (2003) report was based on data collected from a two–year longitudinal study of 40 pupils' explanations of everyday phenomena. After an introductory interview, he taught one instructional unit of three lessons each semester. He then interviewed each student approximately two months after every intervention. Data were collected in instructional units and in four interviews with each pupil from age 10 to 13 years. In the 1st and 3rd interviews the same materials were discussed: a sealed box with soil, a burning candle, and the smell of sweets. During the 2nd interview they discussed the burning of petrol and a piece of rusty iron. The concept of chemical interactions was not introduced until the last instructional unit. In the previous lessons the pupils were challenged to describe what happened when they mixed some everyday substances. In the interviews the children met new situations where chemical reactions were involved.

Students interviewed showed that it was possible to use everyday material and situations when teaching and discussing about how substances interact, or how new substances were formed as a result of chemical reactions in the early age in school (Eskilsson,

20003). A study conducted into the understanding of primary student teachers of the process of distillation, Valanides (2000) reported that some of the students saw boiling to be chemical change where gases of oxygen and hydrogen are produced. This was an indication of their inability to understand boiling as physical change. When alcohol solution was considered, 25% of them insisted that the distillate would be the same mixture of water and alcohol. Fifteen percent of them believed that when mixing water and alcohol, a chemical change occurs and a totally new liquid is formed. Some of them expressed an *additive* rather than an *interactive* conception of chemical change (Valanides, 2000). Most students were not sure whether chemical change occurs during the process of brewing tea; but they felt that the colour itself changed the nature of the liquid, which is similar but different from water. Students believed that the colour of red wine was related to the nature of the liquid that is found in red grapes. They stated that it is impossible to produce red wine from white grapes. None of them mentioned alcoholic fermentation, which is a chemical change. Furthermore, students believed that the colour of coke ‘‘was chemically added’’ in factories, but ‘‘once a liquid is coloured, a totally new liquid was formed, and it is impossible to obtain a colourless liquid by distilling it’’. Some of the students (3%) thought that a chemical change occurs when salt is dissolved, sugar (3%), or alcohol (15%) in water, and that the initial materials do not exist any more and a new material with its own properties will be formed.

Valanides (2000) concluded that the students face difficulties in understanding the essential changes during chemical transformations of matter that involve the breaking apart and recombination of molecule and therefore, are unable to differentiate chemical from physical transformation where the structure of the molecule is unaffected. Martin del Pozo and Porlλn (2001) reported on Spanish prospective teachers' ideas about teaching the concept of chemical change to their pupils and concluded that only half (12 out of 24) of the students explicitly formulated the concept of chemical change they expected their 13-14-year pupils to know. They stated specifically that they expected their children to:

> (i) realise that in physical changes the nature of the substance does not vary (although its appearance does) while in chemical changes the nature does, and (ii) the children will have to come to the conclusion that the new substance which has been formed has characteristics which are different from initial substance. These formulations were at the macroscopic level, in terms of change in identity of initial substances rather than of conservation (of the elements), in contrast with physical changes.

Methodology

The stratified random sampling method was used to select the sample. This permitted the investigator to select from subgroups of the population. Secondly, it ensured that each member of the population had the same probability of being selected. The Awutu-Effutu-Senya District is officially divided into six educational circuits. These are Winneba East, Winneba West, Senya, Awutu, Bawjiase and Bontrase circuits. All JSS 2 and JSS 3 students in the district formed the accessible population. Junior Secondary schools in each circuit were classified as well-endowed or poorly-endowed. Twelve schools were

used for the main study. Out of these 12 schools, six were classified as well-endowed and another six as poorly-endowed.

A table of random numbers was then used to select the schools and the students that took part in the study. A sample of 20 students was selected in each form, thus a total of 40 students were chosen in each school to take part in the exercise. The overall sample size that was used in this study was 464 made up of 235 students from well-endowed and another 229 students from poorly-endowed JSS schools in Awutu-Effutu-Senya District. A total of 96 students who were randomly selected from the participants took part in an interview. The 96 interviewees made up of 48 JSS 2 and 48 JSS 3 students; four students from each participating school.

The instruments

Many of the international, well-validated instruments used to study understandings of science concepts have weaknesses (Leaderman, Wade & Bell, 1998). Questions are often closed and use multiple-choice format, which often limit the information that can be obtained from participants. This is avoided in the current study by using two structured instruments. One was a test and the other an interview schedule. The interview schedule was added after a pilot study was conducted using 120 students from 4 schools in the Awutu Circuit in the Central region. The test that was used for the pilot study was modified for the main study.

The test that was developed and administered to the chosen sample consisted of 11 items in total, with 10 close-ended items under Section A and one short open-ended item under Section B. The open-ended question measured the students' understanding of chemical change and required the students to explain the source of the black substance deposited on the glass rod held in the candle flame. The interview guide consisted of the item in Section B of the test. The purpose was to compare students' verbal responses in the interview with their written texts.

Validity and reliability of the instruments

The method for establishing or evaluating the reasonableness of test content is usually by expert judgement (Shepard, 1997). The test items and the interview guide were before use, submitted to a three-man panel from the Faculty of Science Education. Two of them were from the Department of Science Education; one other expert was from the Department of Mathematics Education. The three experts validated the instruments for content, and face validity. Their suggestions were used to modify the final testing instrument and interview schedule before they were administered to the study sample.

The estimate of the internal consistency of the achievement test was determined through the application of the Kuder-Richardson 21(KR-21) formula and Cronbach alpha coefficient. Using Kuder-Richardson 21(KR-21) formula, a reliability coefficient of 0.84 was established for the multiple-choice set of items (Section A) of the test. Using Cronbach (1951) formula the reliability of Section B was obtained to be 0.78. These two internal consistency coefficients were evaluated by employing the SPSS computer programme.

Administration of the instruments

The data collection process was divided into two parts. The first part involved the administration of the test and the second part was the interview. Students were allowed 60 minutes to give their responses to the test items. The test was administered as a written task. The sampling and administration of the test and face-to face individual interviews were carried out on the same day. This ensured 100% return of the responses. The interview time per student was between 5 to 10 minutes. Interview results were hand-recorded in a small notebook.

Results

The t-test statistic for independent samples was used to test the null hypothesis of research question. Scores were tabulated and converted into percentages to analyse the research question. The scoring for the multiple-choice items was on the basis of one mark for a correct response and a zero score for an incorrect or no response. The data from the test were coded and quantified, and then recorded on data summary sheets, following the format required by the Statistical Package for the Social Sciences (SPSS), computer software for windows described by Bryman & Crammer (1990). The data were subsequently entered into the computer and the SPSS was used in the statistical analysis.

A t-test analysis at a significant level of 0.05 was therefore performed to test the independence of the variable type of school against performance of students' on the concept of chemical change. For scores of Section A were added to that of Section B for computing the t-score.

Students' performance on chemical change

The research question, ''do students of well-endowed and poorly-endowed Junior Secondary Schools have significantly different ideas about chemical change'', was answered by using data results of items under Section A and one question under Section B of the test.

Table 1 **Type of school and distribution of students' percent scores for Section A of the test on chemical change.**

Item No.	1	2	3	4	5	6	7	8	9	10
Well-endowed school	50	44	58	43	47	47	32	41	50	18
Poorly-endowed school	34	31	36	33	33	27	29	17	43	12

Scores are expressed as percentages (%). See Appendix B for items numbered 1-10 on chemical change.

The data collected on the study showed that overwhelming majority of the students had one or more on misconceptions incorrect. Fifty-eight percent of students from well-endowed schools had item 3 correct whilst only 36% of students from the poorly-endowed schools had that item correct. Again 50% of the students of well-endowed schools had items 1 and 9 correct. These were the only items in which students faired well. Students of both well-endowed and poorly-endowed schools performed poorly on the concept of chemical change.

Table 2 depicts the results according to types of schools and a summary of students' performances on chemical change for both Sections A and B of the test.

Table 2 Type of school and students' performance on chemical change

Type of school	n	M	S^2	SD	df	t(cal.)	p-value
Well-endowed	235	2.18	2.31	1.52			
Poorly-endowed	229	2.15	2.62	1.62	462	0.21	$p<.05$

Theoretical $t \leq 1.96$, $p > .05$, n = sample size, M= mean performance, S^2 = variance, SD= standard deviation, df = degree of freedom and t (cal) = calculated t-value.

The performance of students in the test was very poor. Less than 50% of the 464 students gave correct interpretation of chemical change. The results in Table 2 showed a mean score of 2.18 for students of well-endowed schools and 2.15 for those in poorly-endowed schools. The difference in their means is 0.03. This suggests that students from well-endowed schools performed much better than their colleagues. None of the two groups obtained an average score of 50% on the test on chemical change, only a few students from either side showed sound understanding of chemical change. Only 15% percent of students from well-endowed schools gave incorrect responses to all items on chemical change, whilst as much as 24% of their colleagues gave incorrect responses to the same items. A t-test was performed to determine whether there was any significant difference between the two groups in terms of the ideas that they hold on chemical change. The calculated t-value was t (462) df = 0.21, $p < .05$ on assumed equality of variances (Popham, 1990). But the theoretical t- value from tables for $n_1 + n_2 - 2 = 462$ is $t_{0.25} = 1.96$ (two tailed). The calculated t (462)=0.21 fell in the region of non-rejection of the null hypothesis that there was no significant difference between the two groups of students in the ideas they have of chemical change at a significant level of .05.

Discussion

Students from well-endowed schools often come from urban areas and are expected to have better or richer language environment than their colleagues in rural areas. Factors such as access to the mass media e.g. newsprint, television and radio broadcast, library

facilities literate parents and educated homes, avenues for social interactions with peers and adults which are more prevalent in urban areas, may contribute to better understanding of science concepts among better-endowed students.

These factors are limited or absent in areas where the poorly-endowed students are found. Based on the background of the two categories of students, it is quite surprising that the two groups are equally credulous in the ideas they have about chemical change and that they hold no divergent ideas on the concept. Their mean performances and standard deviations are very close which suggest that the two groups have similar ideas and knowledge of this concept. The SPSS computed t (462) = 0.21 is less than the theoretical value at 5% level significance. The slight differences in their means and standard deviations could be due to measurement errors. It was discovered that students from both sides hold certain misconceptions about chemical change.

The most common misconception found among students was that the burning candle was only physical change, because the candle has undergone a phase change. The source of this misconception could be the fact that one could see the wax in a different form during and after the burning process. This idea was noticed in both the written work and during interview. It was coincidental that about 42% of students from both categories of schools harboured the notion that only physical change occurs in a burning candle as revealed by Table 3. This misconception might have arisen because students thought that at the end of the burning process one could still retrieve pieces of wax from the burnt candle. Similar ideas held by children of such an age group (15 to 18 years) were reported by Abraham *et al*. (1994). According to these authors, students indicated that it was the wick that was being burnt, not the wax, while others concentrated on the rod and said it as unchanged. Though 44% of students from un-endowed schools, during interview responded that a burning candle is an example of chemical change, further probing showed that only eight percent of them had the right notion of chemical change (see Table 3).

When students were asked to comment on what made a glass rod held over the flame of the burning candle to become darkened, varying and divergent views were expressed. The following words: smoke, heat, fire, flame, vapour, gas and air were identified from students' scripts as being what caused the blackening of the glass rod. Two percent of the students from the poorly-endowed schools remained silent on the issue. Table 3 shows type of school and percentage distribution of students according the views they held on what caused the darkening of the rod that was passed through the flame of a burning candle.

Table 3 Type of school and percentage distribution of students based on their held notions of what caused the glass rod to darken

Type of school	Smoke	Heat	Fire/flame	Vapour	Gas/air	Silent
Well-endowed	33.70	31.70	19.52	9.76	3.88	1.00
Poorly-endowed	35.18	29.35	22.03	6.45	4.00	2.00

NB: All numbers are in percentages (%).

Many of the students held the view that smoke deposits on the glass rod caused the blackness. This idea was found to be common among students from the two categories of schools. The results revealed that 33.70% of the students from the well-endowed schools said the cause was due to smoke whilst 35.18% of students from the other category of schools were of the same view. Other students had the misconception that it was heat (29.35% of well-endowed and 31.70% of their counterparts); still others said it was fire and or flame, which made the glass rod to blacken. These misconceptions were seen to run through all grade levels and among students from both categories of schools.

The following two unedited statements were sampled from such students.

(1). ''When the candle is cover by the glass rod the heat turn to wax and goes on top of the glass rod and black it".

(2). "The black film on the rod is the vapour of the candle flame' and the black film on the rod formed because there is no air passing between the flame and the rod".

Some students attributed the black substance on the glass rod to vapour from the candle. The percentage of students who held this view was 6.45% and 9.76% for poorly-endowed and well-endowed schools respectively. The following written expression of a student of an endowed school declares his misconception about the concept. "The black film on the rod is the vapour of the candle flame, and the black film on the glass rod formed because there is no air passing between the flame and the rod".

Others too expressed the view that gas or air coming out from the flame of the candle caused the rod to blacken. Four percent and 3.88% of students from poorly-endowed and well-endowed schools respectively held such a notion. The statements made on this view were however weak to actually tell whether they meant that the air carried soot, which could have been the particle that caused the blackening of the rod. The following expressions below are culled from such students.

"The source of the black film on the glass is the air coming out from the flame" and "the black film on the glass rod is that there is carbon dioxide air in the candle or the rope of the candle and cause the rod to black". Such students hold the misconception that carbon dioxide gas is embedded in the candle. This misconception might have arisen due to formal taught knowledge that, when substances burn, carbon dioxide is produced, but which was not well understood by the students.

Similar naive ideas held by students on chemical change were noticed by Abraham *et al*. (1994). Some of the students (2%) who reported that chemical change occur in a burning candle, had a misconception of the process itself. To them the process was a chemical change because the candle goes into liquid form.

The interview revealed how student's uncertain beliefs could be changed through verbal interaction with them. Students may mention that chemical change occur in a candle that is burning but that does not necessarily mean that they have sound knowledge of the process of chemical change. Further probing could reveal surprisingly, the wrong notions that student have of the concept. For instance, when students were asked during interview, what they thought the process of burning a candle could be, some quickly said it was chemical change. When they were further asked to explain what they meant by

chemical change, various interpretations were given. Some of these ideas were culled unedited from their statements and are listed below in italics.

The process is chemical change because:

(i). You see the candle burning and all of it goes down.

(ii.). When it is burning you cannot see the burning.

(iii). You cannot get the candle back again.

(iv). The candle is spoiled.

(v). It goes into liquid form or the candle melts.

The above examples illustrate how students might conceptualise taught science in terms of the frameworks of their existing conceptualisations and result in powerful conceptual outcomes. These predictions and explanations of students are not in conformity with formal science and sometimes are very difficult to break by traditional lecture methods. Table 4 gives the percentage distribution of students with varying ideas about chemical change in burning candle. Though 42% of students from the well-endowed schools alluded to the fact that burning of a candle is an example of chemical change, only 11% of them actually had sound knowledge of the concept. The remaining 31% though said the process was chemical, gave varying unscientific explanations of the concept. Such a group has been classified as those with misconceptions of chemical change (cc*) in Table 4. A typical statement was "it is chemical because when it is burning you cannot see the burning". Only 8% out of a total of 44% of the poorly-endowed school students who said that chemical change occurs in a burning candle had sound knowledge of chemical change.

Table 4 Type of school and distribution of students according to their held notions on the process of chemical change occurring in a burning candle

Type of school	CC	CC*	PC	NI	Total
Well-endowed	11	31	42	16	100
Poorly-endowed	8	36	42	14	100

Note : A ll numbers are in percentages(%).

CC → those who have sound knowledge of chemical change process.

CC* → percentage of those who responded 'chemical change' during interview but had misconception of chemical change process.

PC → those who said the process is physical change.

NI → those who have no idea of the process occurring in a burning candle.

It was coincidental that about 42% of both well-endowed and poorly-endowed school students harbour the notion that physical change occurs in a burning candle. This misconception might have arisen because students think that at the end of the burning process, one could still retrieve pieces of wax from the burnt candle. Some of them said it was physical change because the black substance deposited on the rod could easily be cleaned from it. Such students might have concentrated on the rod itself and hence concluded that still the rod was still available the process was a physical one. The students indicated that it was the wick that was being burnt and not the wax; while others concentrated on the rod and said it was unchanged. Eight percent of the poorly-endowed

school students had the right notion that chemical change occurs in a burning candle though 44% of them during interview responded that a burning candle is an example of chemical change.

Conclusion

The results have demonstrated that the concept of chemical change is one that holds both instructional and curricula significance, as described by Eskilsson (2003), Johnson (2000), Anderson (1990), Anderson & Smith (1987) and by Hollon and Anderson (cited in Hess and Anderson, 1992). The misconceptions found in this study on chemical change meet the requirements for instructional significance because (i) such misconceptions are believed by many students, (ii) they are held by deep conviction and cannot be easily abandoned, and (iii) they hold the promise of being change with proper instruction. The patterns in students' responses in the study demonstrate that this concept also holds curricular significance. To hold curricular significance the naïve concepts must involve concepts fundamental to the discipline.

Many of the explanations given by students to chemical changes, and phase changes due to burning are incompatible with atomic molecular theory, which pervades all of chemistry and part of biology and physics. The confusion over what kinds of explanations are acceptable for chemical change highlights a larger problem how students explain all scientific phenomena.

Analysis of interview indicated that there were some students who had fair knowledge of chemical change but could not express such ideas in written form. This situation was the same for both groups of students.

Though the sample of the study is small and the result could not represent the general situation in Ghana, the findings provide some clues on the differences that can exist between endowed and not-endowed schools outside the sampled area with respect to the three concepts studied.

Recommendations

In the light of these findings, further investigations, which seem warranted include:

1. The need to use a larger sample in order to obtain a clearer picture about the type of schools students attend and their corresponding academic success.
2. The need to extend this type of study to all the ten regions of Ghana using a variety of school science content to identify commonalities and differences in an attempt to enable the generalizability of the findings.
3. The universities of Winneba and Cape Coast should carry out research into science topics that teachers find difficult teaching at the JSS level; and include such topics in their undergraduate programmes for pre-service teachers.
4. In view of the poor performance of students in general and those of the poorly-endowed schools (they are more likely to make erroneous interpretations) in particular, there is the need to research into conditions that affect students understanding of science concepts by JSS students in deprived areas.

5. There is also the need to research into post-secondary teachers' understanding of basic science concepts for they form majority of the teachers who teach science at the JSS level in Ghana. Such a study should aim at setting up in- service training programmes to help improve their lot.
6. Science teachers on their part should make strenuous effort in confronting students' misconceptions. It is a good strategy in class to make the child aware of his /her misconceptions and guide him/her to actively take part in criticising and revising the misconception.
7. Classroom teachers should consider using verbal interview as an evaluative tool for their continuous assessments since some students are more able to express themselves better in verbal interaction than in written expression.

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Bridging the Gap between Scientists and Science Educators' Policies and Practice: A Ghanaian Experience

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Background

The development and application of science and technology are vital for a country's overall economic development strategy and policy aimed at improving the living conditions of its people (Agrawal, 1999; Ramanathan 1999; National Science and Technology Policy, 2000). Science and technology thus have to be given a high priority in any country's development efforts. Since Ghana attained independence in 1957, it has pursued various macroeconomic and development strategies including the adoption of science and technology and industrialization policies.

In Ghana, there are established specific institutions for the development of scientific and technological capabilities in research and development, industry and the provision of essential services. For example, the Council for Scientific and Industrial Research (CSIR) with 13 institutes, the Ghana Atomic Energy Commission (GAEC), the Ghana Standards Board, and other agencies including non-governmental organizations, undertake research and service activities in science and technology. In addition, the tertiary institutions of Ghana (universities and polytechnics) provide training and other human resource development capabilities in science and technology. Other specialized institutions including the Ghana Regional Appropriate Technology Industrial Service (GRATIS) with its Intermediate Technology Transfer Units (ITTUs), the National Board for Small Scale Industries (NBSSI), the Technology Consultancy Centre (TCC) and the Development and Application of Intermediate Technology (DAPIT) also exist for the development and transfer of technologies to all sectors of the national economy (National Science and Technology Policy Document, 2000).

In spite of the considerable science and technology infrastructure establishment over the years, the advancement and progress of science and technology in Ghana has been greatly hampered. The major constraints to the advancement are:

- Inadequate funding (resource allocation to science and technology fluctuates between 0.3 and 0.5% of DGP, well below the target of 1% prescribed at the Summit of African Heads of State in 1980 under the Lagos Plan of Action).
- Weak coordination and integration of science and technology activities.
- Absence of a system allowing for central advocacy for science and technology at the highest level of decision making.

Rationale for bridging between scientists and science educators

Rapid change is taking place around the world and is transforming industries, institutions and governments. The world is shrinking and economies are becoming more global due to breakthroughs in transportation, communications and information science and technology. Advances in medical technology combined with fundamental discoveries on the molecular basis for disease are transforming healthcare. Environmental progress is being supported by increased sophistication in understanding the complex biological and physical processes vital to maintaining biodiversity and healthy ecosystems. A stream of new materials is enabling advances in electronics, transportation, health, construction and sports and recreation. These changes as well as others continue at a rapid pace as new knowledge pushes existing technology to new limits.

These changes are the outcomes of scientific research. Through the activities of scientists, the intricacies of nature are unravelled and applied in what we call technology to harness the numerous opportunities nature has provided continue at a rapid pace as new knowledge pushes existing technology to new limits.

The dynamic process of creation and renewal is transforming the environment we compete in. Children enter a world that redefines itself almost daily as a result of rapid-paced scientific and technological advancement. The ability to compete for high quality jobs and to lead productive lives depends on literacy in a multitude of fields, especially science. Science and technology are major cultural products of human history, and all citizens independently of occupational needs should be acquainted with them as elements of human culture (Sjoberg, 2002).

Wright (1999) summarizes the importance of science and technology information as:

- To improve ones competence as an enlightened consumer of certain products and gadgets.
- To promote responsible behaviour/habits in relation to the natural environment.
- To satisfy one's curiosity about certain phenomena and processes which are currently a source of puzzlement.
- To improve performance in occupational tasks, through better understanding of the rules for good health, etc.
- To develop appropriate competence as a professional in some field of work, which involves a major knowledge of science and technology.

Scientific breakthroughs become useful only if they are accessible and comprehensible to society, and to improve the standard of living and longevity. Scientific knowledge is often incomprehensible to the non-scientist. The role of the science educator is therefore to make meaning to the citizenry outcomes of scientific investigations.

I hereby highlight the importance of science education to the society:

- Scientific and technological advances occur rapidly in our world today; therefore it is essential that students be equipped with the skills to interpret and apply these

advances and to think critically and independently, analyze, question and be creative.

- Due to the demands of an increasingly complex and technologically oriented society, it is vitally important that citizens become self-sufficient analyzers of their environment. As such, the rationale for all science courses is to address the need to develop in students, knowledge and skills needed to understand and solve complex problems related to their physical and biological environment.
- Science teaching is to build a foundation of basic concepts by encouraging higher order thinking, using science content, and emphasizing the relationship between science content and life activities.
- Science education develops an understanding of the natural and physical worlds in which we live, the relationships among the phenomena of those worlds, the effects of those worlds on human living and explains how human living affects the natural and physical worlds.
- Science processes are used to gather information, create and evaluate hypotheses, pose theories for understanding the world in which we live and communicate these theories to others.
- Students should come to understand that science is an intellectual and social endeavour, a means by which we gain an understanding and control over real-world situations, as well as part of our effort to survive and flourish.
- Science technology is the application of science to solve everyday challenges, and technology is ever changing and expanding, students need to recognize that science and technology will play an increasingly important role in all aspects of our society.

Reasons for existing gaps between scientists and science educators

In Ghana, there is no known national policy that seeks to bridge the gap between scientists and science educators. The gap is even widened due to the fact that:

- Institutions/Departments responsible for the training of science educators are often remote from those involved in training scientists.
- Lack of platform for dialogue between scientists and science educators.
- Gap between science curricula and industry.
- General disregard of the teaching profession.

Mechanisms/strategies for gap bridging

- Science education departments to have closer links with science faculties and institutions.
- Science educators should be trained first as scientists before specializing at the post-graduate level.
- Gap-bridging between school science curricula and industry (see Anamuah-Mensah and Asabere-Ameyaw (2004); Alexandre and Oliver, 2004).

- Integration of modern technology into teaching.
- Regular workshops/seminars involving scientists and science educators.
- Regular meetings between Deans of Science and Science Education faculty members to discuss issues of common interests.
- Involvement of scientists in school projects and in the popularization of scientific findings in schools.

Science, Technology and Mathematics Education Policy in Ghana

The principal thrust of Ghana's science and technology policy is to utilize science and technology for economic and social growth; it therefore pervades all sectors of the economy. The objective of the education component of the National Science and Technology Policy is to orient all levels of Ghana's educational system to the teaching and learning of science, technology and mathematics in order to accelerate the acculturation of science and technology in society and to produce a critical mass of requisite human resource and well informed citizenry. The strategies to be used to ensure the achievement of this objective as have been listed in the National Science, Technology and Mathematics Education Policy Document (2002) are:

- Strengthening of science and mathematics education at all levels, and in all aspects of the educational system, especially at the basic and secondary levels.
- Promotion of technical and vocational education and training to enhance middle level management in science, technology and mathematics delivery to all sectors.
- Promotion of science, technology and mathematics innovativeness within the educational system.
- Ensuring that by the year 2020, 60% of all students in the universities and 80% of those in the polytechnics and vocational institutions are registered in science and science related disciplines.
- Creation of special incentives for students and graduates of science, technology and mathematics.
- Ensuring that adult literacy classes include studies into the cause and effect relations and how things work.
- Resource mobilization for science, technology and mathematics development

Major challenges faced in the teaching of science

- Limited infrastructure and equipment
- Obsolete equipment
- School curricula that have very little relevance to the needs and aspirations of learners and the society.
- Large numbers of low self-esteemed students.
- Students with limited horizon.
- Large numbers of students with little or no interest in the courses they are pursuing.
- Large classes.
- Large number of teachers are either teaching out of their fields or have not specialized in their teaching subjects, especially at the primary and lower secondary levels.

- General high cost of education.
- Low remunerations and incentives for scientists and science educators.
- Negative perceptions of the society on scientists and science educators.

SACOST and the contextualization of the teaching of science

It is generally known that relatively few students in secondary and tertiary educational institutions in Ghana take up programmes in science and technology compared to those who take up other programmes. The low interest of students in science and technology can be traced to the foundations in these subjects that the students had as pupils in basic schools. School science and technology curricula, including those of basic schools, have not taken the indigenous knowledge in science and technology as well as informal and formal industrial experiences which pupils and teachers can relate to, into consideration. The result is that school science and technology curricula in use lack relevance and meaning to pupils and teachers alike. Pupils therefore, are not able to grasp the science and technology concepts they are taught. Most pupils lose interest in the subjects, right at the basic level, and would move away from them at the earliest opportunity.

To remedy this unfortunate situation and generate interest and relevance in school science at the basic and higher educational levels, the African Forum for Children's Literacy in Science and Technology (AFCLIST) set up a centre of excellence, Centre for school and community science and technology Studies (SACOST Centre) in the University of Education, Winneba (UEW) in June 2000. The Centre was established to develop innovative approaches that contextualize the teaching and learning of science and Technology in schools. SACOST is adopting a number of different approaches to fulfil this objective.

SACOST has established permanent agreement with the National Board for Small Scale Industries (NBSSI) and the Ghana Regional Appropriate Technology Industrial Service (GRATIS) to develop materials for schools, and ensure that students have relevant hands-on experiences through attachments at the regional networks of Intermediate Technology Transfer Units (ITTUs) set up to help develop informal technologies in the country through training and improvement in the technologies. In addition, SACOST and GRATIS have agreed to develop multimedia teaching and learning materials.

Among the various activities that SACOST has undertaken since its inception in 2000, is the production of video documentaries on endogenous activities e.g. kenkey production, palm oil production, traditional tanning, blacksmithing and beads making). These documentaries are to sensitize learners to basic science concepts and technological processes in indigenous/informal activities that go on in their communities to activate their prior knowledge for effective learning.

The unique characteristic of all the documents SACOST has produced on indigenous knowledge systems is the provision of tables in which the indigenous and scientific explanations of all processes in the selected indigenous activity are included. The tables also contain the related school concepts and the technologies used in the processes. These tables are intended to draw the attention of the teacher and learners to the science and

technology concepts that are utilized in indigenous/informal activities which can provide the baseline for the study of school science.

These manuals are supposed to be used to supplement the existing recommended textbooks in use but not to replace them. It is hoped that they will help teachers to contextualize their teaching to facilitate learning among their students. To learners, the manuals and documentaries should provide the contextual framework for effective learning of science and technology.

Conclusion

It is increasingly recognized today that the complex relationship between the economy, society, the environment and scientific knowledge requires a multidisciplinary approach, and calls for skilled communicators to make science and technology concepts, gadgets/tools and processes accessible (Ramanathan, 1999; Miranda *et al*., 2004). For Ghana to realize accelerated development and scientifically literate society as envisaged there is the need to be cooperation between her scientists and science educators and the consumers of the products of science.

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Establishment of Average Body Measurement and the Development of Block Patterns for Pre-School Children

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Abstract

There is a need for mass production of garments for pre-school children to meet their clothing needs. Clothing has been included in some of the items banned from importation in order to save foreign exchange for provision of raw materials for the manufacturing sector in Nigeria. The purpose of this study was to establish average body measurements of pre-school children of ages 2 to 5 years, adapt block patterns for them and standardize the patterns drafted. Fifteen design criteria based on comfort were utilised to standardize the patterns drafted. The population of the study comprised all pre-primary school children in the 180 schools in Cross River State of Nigeria. The sample consisted of 400 pupils. Prototype garments were produced and modelled by four pre-school children of ages 2,3,4 and 5 years. The garments were evaluated by five judges. Results after analysis of data with mean and ANOVA provided average body measurements and also indicated that the patterns developed were appropriate for the target group. The results also showed that there is no significant difference in the mean body measurement for height and backneck to waist for ages 2,3,4 and 5 years. The average body measurements obtained are therefore recommended for drafting and adapting patterns for the target group and the standardized block patterns are also recommended for clothing manufacturing companies.

Introduction

A pre-school child is a child between the age of three to five years old (Federal Republic of Nigeria (1998). Pre-school children according to Bray (1999) grow all the time. As they grow there is a change in their shape as well as in their size. This growth according to Aldrich (1999) decreases as they approach puberty and is similar in both male and female children. At puberty children experience a growth spurt. Pre-school children have certain rights which include the right to clothing (United Nation Children Education Fund (UNICEF) 1989).

Clothing is anything worn for protection (Clayton 1994). Clothing also does more than just meeting individuals' need for comfort and protection but also gives a first impression. Clothing helps in self-expression and communicates messages to other people. It also reflects personality and life style. Through clothing basic human needs are satisfied which are both physical and socio-psychological (Johnson and Forster 1990). Some of these needs as earlier stated include protection from rain, hot sun and cold weather. Hurlock (1978) observed that clothes give children impression of growing up, help children to identify themselves as individuals and help camouflage their physical defect and disabilities among others. Sasse (1997) also stated that clothing helps children

to be independent at an early age. This sense of independence and a sense of pride produced by clothes are important for a childs emotional development.

Children's wear is no longer a neglected area of design. Designers of children's clothes should be aware of the way that a child's body grows and should be able to recognise the shape of child at a particular state. Children's wear offers special opportunities to designers to experiment with colour decoration and design detail (Aldrich 1999).

Patterns for children are cut very much as patterns for adults using the same basic methods of style and pattern adaptation. Children's styles are even simpler and less varied. Pattern drafting according to Tuit (1983) is a method of obtaining patterns by working from the measurement of a figure according to a set of instructions and drawing a shape on paper or card. It is also a process of obtaining component parts of a garment silhouette in shapes of paper following lines that relate to the body contour (Utuk 1991). The shape of the pieces of paper when tested according to her are then laid on the fabric and cut out for clothing. Cooklin (1994) sees pattern drafting as a bridge function between design and production based on a sketch which can be turned to a garment. Igbo and Iloeje (2003) however stated that pattern drafting is an engineering approach to the production of pattern based on a set of body measurements and instructions. Patterns for clothing production can be obtained in the following ways, flat pattern method, knock off design, and the computer aided design (CAD) (Hollen and Kundel 1993). Patterns help in mass production of children's dresses.

The advent of Globalisation which means a world liberalized of barriers to trade and investment in which corporations can produce and sell almost any goods and services anywhere in the world has led to many mass produced children's clothing from the far East and developed world finding its way into Nigeria. Globalisation according to Ayodele (1995) has brought about increased movement of goods, services, capital, people and information across national borders. However during the announcement of the annual budget for the year 2004, President Obasanjo of Nigeria announced the ban on the importation of certain goods which include clothes and textiles thereby encouraging Nigerians to go into mass production of clothing items. Mass production of clothes is only possible with the use of patterns. Many of Nigerian's indigenous tailors, and seamstresses are trained to make made-to-measure dress items without the use of patterns. (Iloeje 1995). Nigerian tailors presently have an odious task in view of their heavy dependence on taking of individual body measurements of customers before constructing dress items for them. This task can however be reduced by the use of patterns which are either commercial or drafted. Commercial patterns are however included in the luxury goods whose importation is banned in Nigeria.

As a first step towards making pattern for pre-school children dresses available to the tailors, average measurements of the different parts of the body must be established. Children of the same height can have varied arm and leg measurements (Aldrich 1999). The environment where a child is brought up can bring about significant differences in height and size. Aldrich (1999) discovered that children of working class parents – the managerial and professional appear taller but not heavier than children of semi-skilled and unskilled parents. Igbo (2002) also stated that environmental factors like adequate nutrition which is in turn affected by availability of and accessibility to adequate food have a part to play in the height and weight of a child. Aldrich (1999) established the

following average body measurements for some body parts for children aged 2,3,4 and 5 respectively: height 92, 98, 104 and 110 cm, chest 53, 55, 57, 59 cm, waist 51, 53, 54, 56 cm, sleeve length 32, 34.5, 37, 39.5 cm. Bray (1999) also stated that some of the special problems in producing children's clothing's is the problem of change in size and shape of a growing child. To deal with problem of changing size and shape, the present study will establish average sizes and proportion which would be used to develop block pattern for adaptation into various styles which will in turn help in mass production of garments for the target group.

However to obtain accurate patterns, accurate measurements must be carried out. Clayfon (1994) stated that measurements should be taken snugly but not tightly over the undergarments. Tapes must be held parallel to the floor during measurement. Without accurate measurements, accurate patterns for mass producing clothing items for pre-school children cannot be obtained. The objectives of the study therefore were

1. To establish average body measurements of pre-school children of ages 2 to 5 years.
2. Determine which body measurements showed marked variation from the group mean.
3. Draft the basic blocks for the different age groups (2, 3, 4 and 5 year olds) – front bodice blocks, back bodice blocks and sleeve blocks.
4. Evaluate the blocks developed for the pre-school children for fit in order to standardize them.

The study also tested one null hypothesis - There is no significant difference in the mean body measurement for height and nape to waist measurement of pre-school children of ages 2, 3, 4 and 5 years.

Methodology

Design of the study

The procedure utilised for carrying out the study was as follows:

1. Taking the body measurement of pre-school children of ages 2, 3, 4 and 5 years old.
2. Obtaining the mean or average measurements of the different body parts measured.
3. Drafting the block patterns.
4. Cutting out and stitching of the garment parts.
5. Modelling of the garment by the pupils.
6. Evaluation of the garment based on an evaluation criteria chart.
7. Obtaining the standardized block patterns.

Area of the Study

The study was carried out in the Cross Rivers State of Nigeria. Cross River is one of the states in the South South geopolitical zones of Nigeria. The state is divided into six educational zones namely Calabar, Akamkpa Ugep, Ikom, Ogoja and Obudu. The study took place in three zonal areas – Ikom, Ogoja and Obudu.

Population of the Study

The six educational zones have 180 pre-primary schools with a population of 20,500 pre-primary schools. Information to this effect was obtained from the state ministry of education office of statistics. Nine thousand two hundred pupils who formed the population of the study were from the three zones that were studied.

Sample for the Study

A multi-stage sampling technique was utilised. Three zones were sampled out of the six zones using stratified random sampling technique. These zones have 88 pre-primary schools. Fifteen schools were randomly sampled from the eighty-eight schools. For the pre-school pupils proportionate sampling was used in selecting 250 children from Ikom zone, 100 from Ogoja and 50 from Obudu to give a total of 400 pupils.

Instrument for Data Collection

A body measurement chart on essential body measurements needed for drafting flat patterns for the study was developed. The instrument comprised two sections. Section A contained background information on age, name of school, local government area and parents profession. Section B contained the body parts that were measured and the measurements obtained. A total of ten (10) body parts were measured namely height, chest, waist, across back, back neck to waist, sleeve length, under sleeve length, arm circumference, wrist and half length.

Data Collection Technique

This was carried out in 3 stages with the help of two research assistants.

1. Background information on the students as seen in section A was recorded.
2. Body measurements were taken over the school uniforms. Cardigans and vests were removed to avoid bulk. Fibre – steel tape was utilised for the measurements of the total 400 pupils and recorded.
3. Means of the measurements of the body parts were obtained and used to draft the front bodice, back bodice and sleeve blocks for the different age groups (2, 3, 4 and 5 year olds) using the flat pattern drafting method.
4. The pattern pieces were cut out on soft plain cotton fabric and stitched to obtain four garments for 2, 3, 4 and 5 year olds respectively.
5. The garments were trued on four pre-school children of ages 2, 3, 4 and 5 years and then evaluated. The evaluation was carried out by five judges based on an evaluation criteria chart. The criteria for evaluation which was based on comfort included the following front neck width, front neck depth, shoulder

seam length, shoulder slope, front chest width, chest line ease, waist line ease, armsyce depth, ease at arm circumference and sleeve cap fullness. The evaluation criteria chart had five point scale items ranging from much too small, slightly too small, satisfactory slightly too large and much too large. The scale was assigned these following scores 1, 2, 3, 4 and 5 respectively.

Data Analysis Technique

The mean was used to analyse the data obtained from the measurement of the following body parts for all the ages – waist, across chest, height, across back back neck to waist (nape to waist), sleeve length, under sleeve length, wrist, arm circumference and half length.

1. A one way analysis of variance ANOVA was utilized to test the null hypothesis at 0.05 level of significance.
2. Mean of the body parts obtained was used to draft the blocks using the flat pattern method.
3. the five point rating scale in the evaluation criteria chart was analysed using mean. Any criteria with a mean of 3.00 was accepted while any below or above was rejected and the pattern piece with the rejected criteria was revisited for correction.

Findings

1. Mean measurements of the ten different body parts were obtained (see Tables 1 – 5).
2. Variabilities were observed in the measurement of the different body parts for the different ages (2, 3, 4 and 5 years olds) see Table 5.
3. There was no significance different in the mean body measurements for height and nape to waist measurement of the pre-school children of ages 2, 3, 4 and 5 (see Table 6).
4. The following block patterns were obtained:
   - i. basic bodice front block
   - ii. basic bodice back block
   - iii. basic sleeve block
5. Based on the scores from the rating scale in the evaluation criteria chart, after the garment has been "modelled" minor adjustments were made on the blocks to produce standardized basic bodice front, basic bodice back and sleeve block. (see table 7).

Table 1 Mean Body Measurements (cm) of 2 year old Pre-school Children

Body measurement	Min	Max	Mean	SE
Waist	51.7	56	54.0	0.19
Across chest	50.4	55	52.9	0.15
Height	82.5	88	85.80	0.13
Across back	20.5	24.5	22.56	0.12
Back neck to waist (Nape to waist)	23.5	27.9	26.0	0.14
Sleeve length	21.5	27.8	24.9	0.21
Under sleeve length	19.5	23.9	22.56	0.30
Wrist	14.00	17.1	15.55	0.01
Arm circumference	16.5	21.8	19.1	0.18
Half length	22.1	25.4	24.0	0.12

N = 100; Min = minimum measurements; Max = maximum measurements; and SE = Standard Error

Table 2 Mean Body Measurements (cm) of 3 year old Pre-school Children (N = 100)

Body measurement	Min	Max	Mean	SE
Waist	58.7	65	61.8	0.17
Across chest	55	59.4	57.2	0.12
Height	99.5	104.8	102.5	0.19
Across back	21.5	25.6	23.8	0.127
Back neck to waist (Nape to waist)	24.5	29.1	20.97	0.14
Sleeve length	28.5	32.7	30.70	0.13
Under sleeve length	23.5	28.3	26	0.1498
Wrist	14.5	17.8	16.1	0.8098
Arm circumference	19.5	24	21.92	0.143
Half length	21.5	25.9	24.045	0.145

Min = Minimum measurement; Max = Maximum measurement; and SE = Standard Error

Table 3 Mean Body Measurements of 4 year olds (cm) N = 100

Body measurement	Min	Max	Mean	SE
Waist	56.8	68.4	61.98	0.32
Across chest	57.1	61.4	59.5	0.13
Height	94	106.8	101	0.42
Across back	22.5	27.2	24.86	0.15
Back neck to waist (Nape to waist)	25.5	29.9	28.0	0.14
Sleeve length	29.5	33.8	31.5	0.13
Under sleeve length	27.5	33.6	30.36	0.186
Wrist	15	18.6	16.14	0.11
Arm circumference	20.4	24.9	22.67	0.1435
Half length	27.5	33.5	30.5	0.34

Min = minimum measurements; Max = maximum measurements; and SE = Standard Error

Table 4 : Mean Body Measurements of 5 year old (cm) N = 100

Body measurement	Min	Max	Mean	SE
Waist	58	67.2	62.96	0.27
Across chest	55	65.4	62.3	0.19
Height	104	109.5	107.2	0.15
Across back	22.5	27.2	24.86	0.15
Back neck to waist (Nape to waist)	27.5	32	29.9	0.1447
Sleeve length	35.5	39.4	37.5	0.133
Under sleeve length	30.5	41.8	35.26	0.428
Wrist	15.5	19.6	17.2	0.118
Arm circumference	21.5	25.7	23.45	0.132
Half length	28.5	33.9	30.63	0.145

Min = minimum measurements; Max = maximum measurements; and SE = Standard Error

Table 5 Mean Body Measurements (cm) for ages 2 – 5 and standard Error of the means

Body measurement	2 year olds	3 year olds	4 year olds	5 ys. olds
Waist	54.0±0.19	61.70±0.176	61.98±0.32	62.96±0.27
Across chest	52.90±0.15	57.20±0.12	59.50±0.13	62.30±0.19
Height	85.80±0.13	101.0±0.40	102.50±0.19	107.20±0.15
Across back	22.56±0.14	23.50±0.13	24.89±0.15	25.9±0.15
Back neck to waist (Nape to waist)	26.0±0.14	26.97±0.14	28.0±0.14	29.90±0.14
Sleeve length	24.9±0.21	30.70±0.13	31.50±0.13	37.50±0.13
Under sleeve length	22.56±30	26.0±0.15	30.36±0.19	35.52±0.44
Wrist	15.55±0.01	16.10±0.01	16.14±0.11	17.2±0.12
Arm circumference	19.10±0.18	21.92±0.14	22.67±0.14	23.45±0.13
Half length	24.0±0.12	24.04±0.15	30.5±0.18	30.63±0.15

N = 400; Min = minimum measurements; Max = maximum measurements; and SE = Standard Error

Table 5 shows that there are variabilities in the following:

i Height (SE = 0.13 – 0.3). which showed the widest distribution of values for the four age groups.

ii Under sleeve length (SE 0.15 – 0.44)

iii. Sleeve length (SE 0.13 – 0.3)

iv. Waist SE (0.17 – 0.32)

v. Across chest (SE 0.12 – 0.19)

vi. Half length (SE 0.12 – 0.18).

vii. Arm circumference (SE 0.13 – 0.18)

viii. Across back SE = (0.12 – 0.15)

ix. Wrist (SE = 0.1 – 0.12) which has the least variability for the four age groups

Table 6 **One-way Analysis of Variance Summary Table examining the difference in the mean body measurement for Height and back neck to waist of pre-school children of Ages 2, 3, 4 and 5 years.**

Variation	Sum of squares	Df	Mean Squares	F. Ratio
Between means	SSA = 173.08	n-1 = 3	MSA = 57.69	$\frac{MSA}{MSE}$ = 0.0224
With samples	SSE = 10286.26	(r-1) n = 4	M.SE = 2571.56	
Total	SST = SSA + SSE = 10459.3	$\frac{rn-1}{7}$		

SSA = 173.08; SSE = 10286.26; SST = SSA + SSE = 10459.3; MSA = 57.69; MSE = 252.56

The above table shows that the calculated F-ratio is 0.0224 since the calculated f-ratio of 0.0224 is less than the tab f-ratio. Hence the null hypothesis was up held. The average body measurements in Table 5 were then used to draft the basic bodice front basic bodice back, and the sleeve block using the flat pattern drafting method. These blocks were then modelled on four children in the different age groups to obtain standardized block patterns, see figs. 1 – 4 and 5 – 8. Standardized block patterns – front bodice, back bodice and sleeve were obtained after, judgement by judges and corrected by the researcher (see figs 1-4).

Table 7 **Mean Responses of Evaluation Criteria by Judges for all ages (2, 3, 4 and 5 years).**

S./N	Criteria	Mean Response			
		2 years olds	3 years olds	4 years olds	5 years olds
1.	Front Neck width	3	2	3	3
2.	Front Neck depth	2	3	2	3
3.	Shoulder seam length	3	2	2	3
4.	Shoulder slope	2	3	3	3
5.	Front chest width	3	3	3	3
6.	Waist line ease	3	4	3	3
7.	Ease across shoulder blades in back	3	4	3	2
8.	Waistline ease in front	4	3	4	3
9.	Waist line ease in back	3	3	4	
10.	Waistline placement in front	4	3	2	3
11.	Waistline placement in back	3	4	3	3
12.	Armscye depth	3	4	3	3
13.	Ease at arm circumference (biceps)	4	3	3	3
14.	Sleeve cap fullness	3	2	2	3
15.	Overall scare of garment	3	3	3	3

Remarks

2 = slightly narrow, short, little

3 = Satisfactory, comfortable

4 = Slight too much ease and low

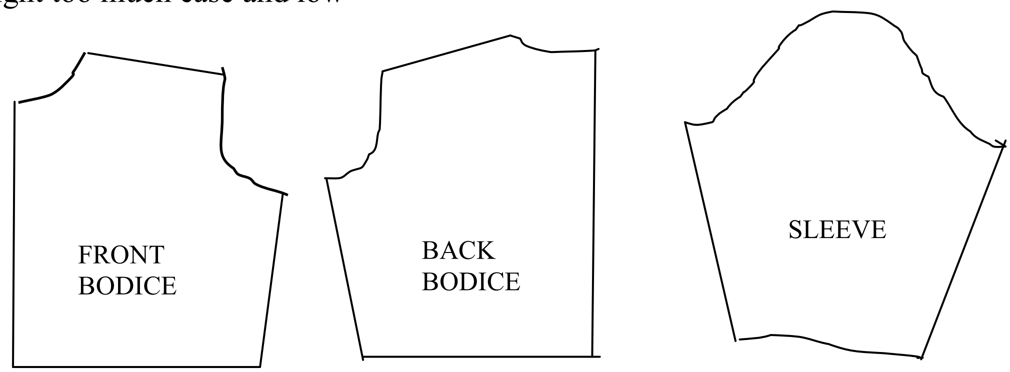
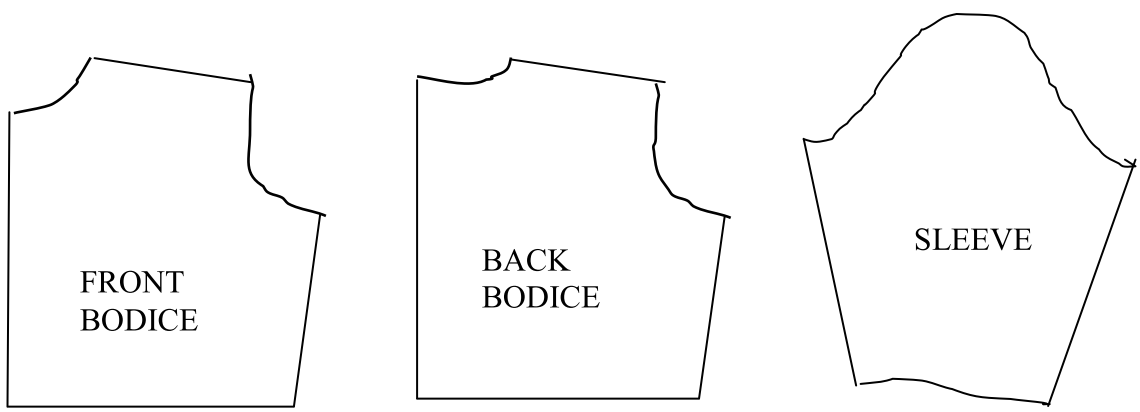
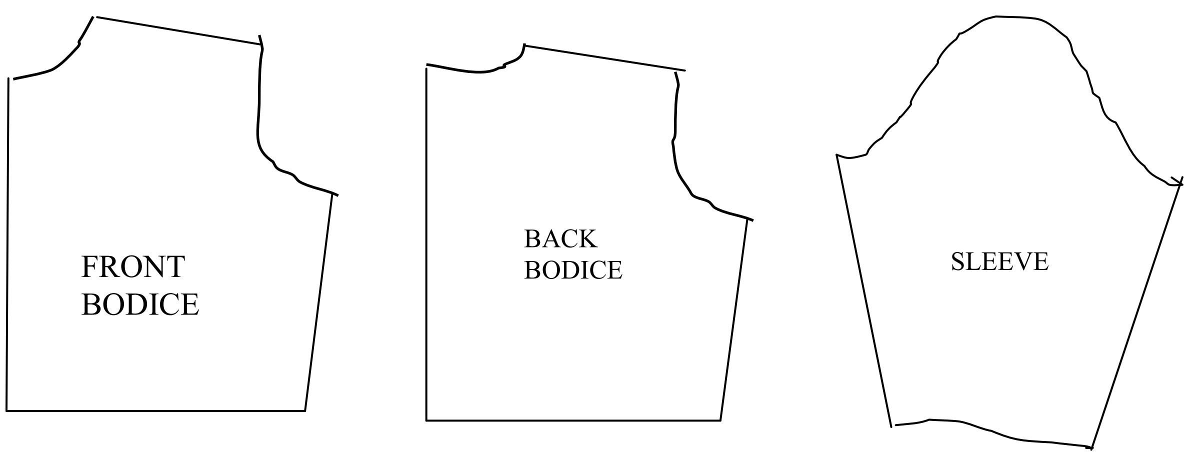


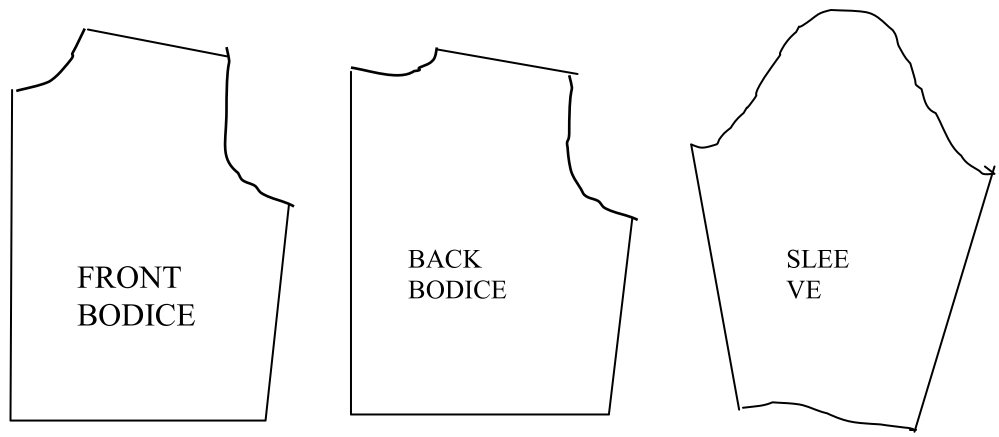
Fig. 1 $\frac{1}{4}$ Block pattern for 2 year



(Fig. 2 $^{1}/_{4}$ block patterns for 3 year olds).



(Fig. 3 $^{1}/_{4}$ block patterns for 4 year olds).



(Fig. 4: $^{1}/_{4}$ block patterns for 5 year olds).

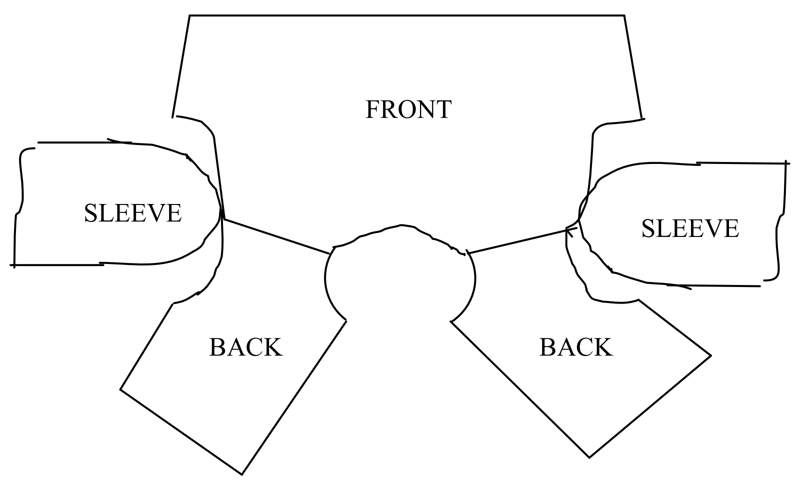


Fig. 5: (2 year olds) $^{1}/_{4}$ pattern

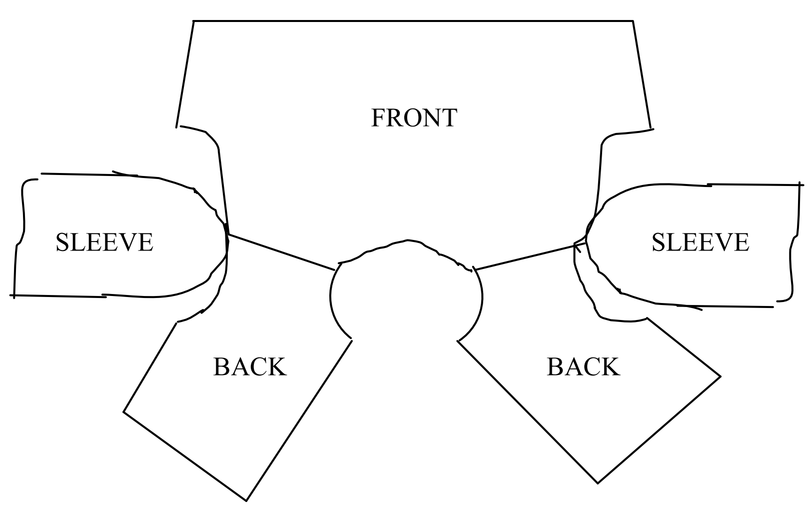


Fig. 6: (3 year olds) $^{1}/_{4}$ pattern

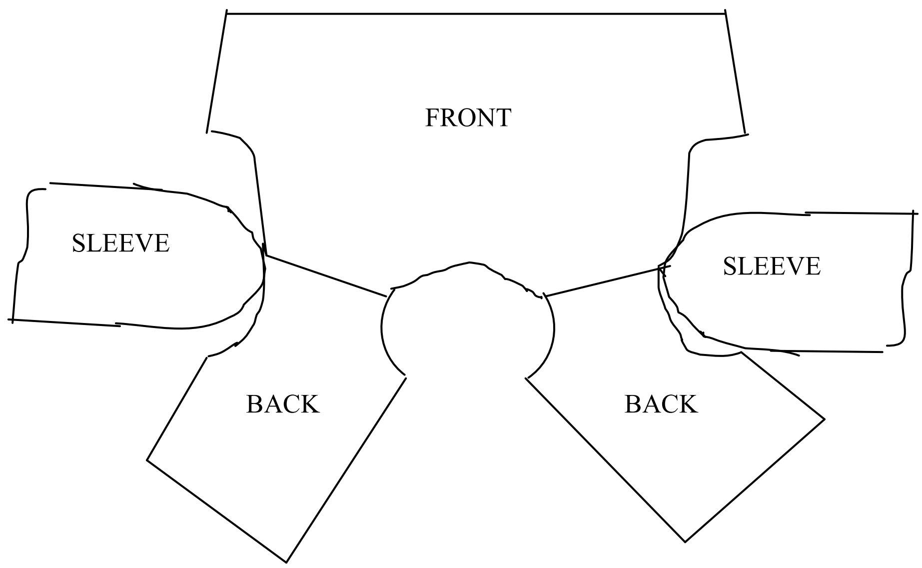


Fig. 7: (4 year olds) $^{1}/_{4}$ pattern

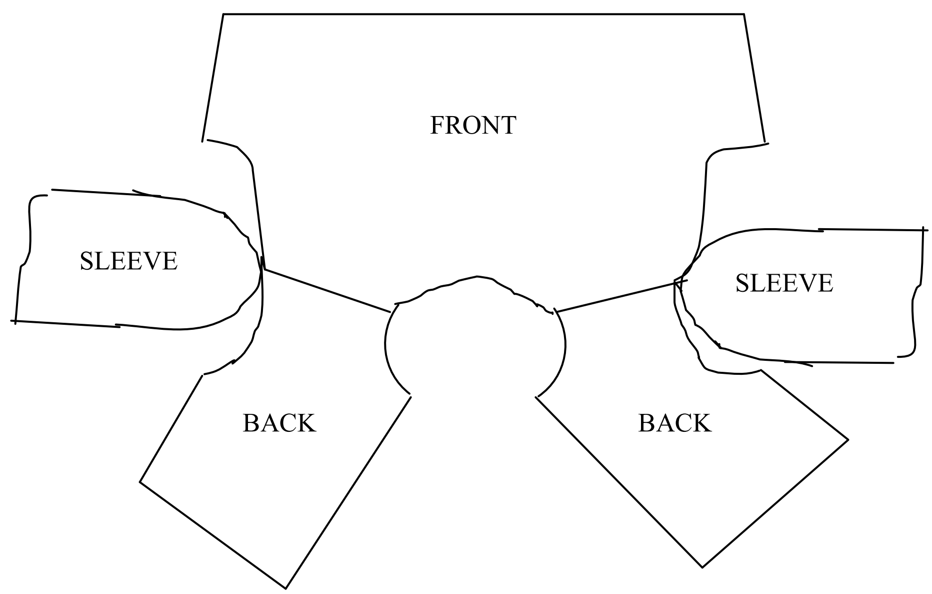


Fig. 8: (5 year olds) $^{1}/_{4}$ pattern

Discussion of Findings

Mean body parts measurement of the group used for the study showed slight differences from those subjects in Aldrich (1999). Differences existed in height, waist, chest, sleeve length, arm circumference, wrist, across back, back neck to nape to waist, under sleeve length and half length. For example average height measurements for the groups under the present study were 85.80, 101, 102.50 and 107.20cm respectively for ages 2, 3, 4 and 5 years while the height for the subjects studied by Aldrich (1999) were 92, 98, 104 and

110 cm. The differences in these average body measurements might be as a result of environmental factors like nutritional status. Nigeria is regarded as one of the poorest nations in the world despite her oil wealth. Poverty according to Igbo (2002) is one of the reason for food insecurity. Inaccessibility and inadequacy of food are also some of the causes of food insecurity.

The study also showed variability in height, under sleeve length, sleeve length, waist, across chest, half length, arm circumference, across back and wrist from the group mean. This is also in line with Aldrich (1999), Utuk (1991) who stated that variabilities often exist in sleeve length for children of even the same age. Aldrich further stated that children born to managerial and professional parents are taller but not heavier than children of semi-skilled and unskilled parents. Waist measurements of subjects in the present study are 54, 61.70, 16.98 and 62.96 cm as against 51, 53, 54 and 56 cm of the children in Aldrich study. This might be as a result of excessive consumption of carbohydrates. Carbohydrate in the form of cassava, yam, potatoes and other forms of carbohydrate are the main staples of Nigerian foods (Igbo 2002). Carbohydrate as a class of food has the ability of making an individual add extra calories if not utilized. The pre-school children studied were thus heavier but not taller. The present study indicated that some of ease at waist line existed for three groups of children which seem to agree with Aldrich (1999) who stated that very little waist shaping existed for pre-school children's garment. She also indicated that the little shaping gave the children a hollow back and protruding stomach which decrease as the children grow older and loosing baby fat. The scores for items six to ten indicated that the hollow effect reduced for the five year olds.

Conclusion

Designing for children can be very challenging because children grow continuously. To meet the challenges of mass producing dress items for pre-schools children average body measurements were taken and standardized and used for drafting patterns which are not easily available in Nigeria. Children measured for this study showed variability in the measurement of the different body parts. To correct the variability, mean of each body part was determined and used for the drafting. Patterns drafted were cut out in soft cotton fabric stitched together and modelled by some of the subjects in the study. Judges scored the fit of the garment produced based on some evaluative criteria. Comments by the judges were utilised to correct some faulty areas in the pattern before obtaining the standard blocks.

Recommendations

Based on the findings of the study the following recommendations were made

1. Mean body measurements obtained could be made available to clothing and textiles students for use in pattern drafting.
2. The block patterns obtained could be made available to textiles and clothing students for pattern drafting.
3. The block patterns could be utilised for pattern alterations.

4. Professional tailors and makers of uniforms for post primary could utilised the standard blocks for mass-producing uniforms.
5. Pattern drafting experts could use the average body measurements to draft commercial patterns.

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Examining the Link between BECE Papers in Mathematics and the Curriculum Standards

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Abstract

This article seeks to explore the relationship between implementation of curriculum standards in mathematics and the nature of Ghana's Basic Education Certificate Examination (BECE). It covers the period between 1992 and 1999. Data for this research were collected from past BECE examination papers. The past examination papers were used to find out whether the BECE examination papers in mathematics reflect the curriculum standards. The examination papers were also used to find out whether the introduction of the mathematics curriculum standards has modified the BECE examination papers in any way. The result from the research seems to suggest that there is little evidence to prove that the BECE examination papers reflect the curriculum standards. There has not been any attempt to make any generalised claims from these finding in view of the limited period (1992-1999) this research has focused on.

Introduction

The advent of school education in Ghana brought a system which considered mathematics as three distinct disciplines: arithmetic, algebra and geometry, where the curriculum was predominantly arithmetic, commonly taught by rote with emphasis on learning standard written procedures. There have been several efforts by successive governments since the colonial era to simplify the teaching of arithmetic and generate positive attitudes by learners towards the subject.

After about a decade (1970s) of attaining independence, Ghana initiated a further strategy towards improving the quality of teaching arithmetic and encouraging pupils to develop interest in the subject. The 1970s might also be seen as the time when mathematics began to become a reality when there was the advent of 'modern mathematics'. This modern mathematics meant different things to people and involved introducing several new approaches into the mathematics classroom. Consequently, a project dubbed the Joint School Project (JSP) was initiated in 1975 aimed at presenting mathematics as a unified subject and seeking to present it as something to be understood rather than just learned by rote. The JSP's intention was also to ground mathematics in the learners' own cultural base where pictures, diagram, learning materials, etc. found in textbooks should not be foreign.

Furthermore in 1987, the then government initiated a curriculum enrichment programme which aimed at creating equal opportunities for all pupils to gain quality teaching and

learning of mathematics. The new label - modern mathematics, and new techniques which were basically learner-centred were adopted. These new techniques involved the teaching of mathematics using a lot of teaching materials, the use of real-life situations, teaching to the understanding of the learners, among others. In the same year (1987) a number of school re-organisation plans were approved. Among some of the re-organisations included a wish to give all children a common curriculum.

In 1990/91 academic year, the Basic School Education replaced the old elementary school system with its ten years duration. In the new system, the first three years are collectively classified as the lower primary, and Primary 4, 5 and 6 through to JSS1, JSS2 and JSS3 (JSS-Junior Secondary School) are classified as the basic stages. The final Basic Education Certificate Examination (BECE) is to be written at the end of JSS3. The first batch of this new system wrote their final BECE in August 1993, without any clearly significant reforms in the existing National Curriculum.

To entrench the equal opportunity efforts, an Act of Parliament was passed in 1994 making basic education free and compulsory for all children of school-going age.

The Mathematics Curriculum standards

In the first place let us consider what a curriculum is. A curriculum, for Howson *et al.* (1981, p.2), is clearly much more than a syllabus, and 'must encompass aims, content, methods and assessment procedures'. McCormick and James (1983) define curriculum in more pupil-centred terms as what is experienced by pupils when they are involved in learning activities and also as the outcome of learning in terms of the understandings, attitudes, etc. that pupils develop. Curriculum has also been defined as a plan for providing sets of learning opportunities for persons to be educated. Plans have no impact until they are set in motion; thus, learning opportunities remain only opportunities until learners become engaged with the opportunities. In my view, all these definitions have merit, but each is too limited. My definition incorporates everything suggested in all of them, including intentions, plans, assessment instruments, classroom teaching practices, pupil experiences and learning outcomes. The thesis of this research is concerned with relationships among different elements of the curriculum, thus broadly defined. Secondly, what should be contained in the mathematics curriculum standards?

The American National Council of Teachers of Mathematics – NCTM (1989) considers that an effective basic school mathematics programme should include dedication to improvement in the teaching of mathematics as a way of thinking and as a tool for problem solving skills. It further stated that the teaching of mathematics at elementary level must give substantial attention to concepts and skills from all strands – number, measurement, geometry, patterns and functions, statistics and probability, and logic. It asserted that these strands are not separate and unrelated mathematical topics but they are arbitrary delineations that frequently overlap. The NCTM (1989) also stated that when a set of curriculum standards are specified for school mathematics, it should be understood that the standards are value judgements. These are based on a broad, coherent vision of schooling derived from several factors such as societal goals, pupil goals, research on teaching and learning, and professional experience.

An area of concern to me is that the mathematics curriculum standards that exist in Ghana, and perhaps in most countries of the world, are perhaps strongly directed towards performance techniques rather than a broader perspective such as societal goals. Arithmetical computation is entrenched as the basis of the mathematics curriculum, with the ‘four rules’ gradually being developed to handle more and more complicated ‘numbers’. According to Bishop (1988), a technique curriculum is a curriculum of procedures, methods, skills, rules and algorithms which portrays mathematics as a ‘doing’ subject. In this case, therefore, he said it is a curriculum in which ‘practice makes perfect’ with examples to be emulated, and exercises to be carried out. He further contended that it involves impersonal learning, whereby the task for the learner is conceived of as being independent of the *person* of the learner. That is, what is considered important is that the learner learns the mathematics *not* that the learner strives for some personal meanings from mathematics. According to him, syllabuses, examinations, textbooks, and teacher are all dominated by the emphasis on subject knowledge and technique performance. To him the third major area of concern is characterised by ‘text teaching’. In Ghanaian educational system there is one textbook and its use is mandatory. The control by the textbook might prevent teachers from knowing their learners and thereby prevent them from helping their learners. Hence in the context of Ghana, the use of textbook is crucial in curriculum development.

The Teacher, Test and Curriculum

There is the problem as to whether teachers teach according to what is generally spelt out in the curriculum or not. The teacher’s role in the classroom has been found to be very crucial in the successful implementation of policies related to curriculum development and assessment. Torrance (1988) has, for example, noted that changes in assessment and especially public examinations impact most positively on curriculum and teaching methods, when teachers have an active role in the development process. He noted:

> Crude changes in curriculum content and teaching methods can be instigated, but the quality of these changes will depend on teacher perceptions of their purpose and understandings of their broader curricular intentions (ibid., p.155).

Thus we cannot talk about the effective use of testing in the classroom without thinking first about how practitioners actually understand the concept of testing and how they use it in the classroom. Available literature cited by Black and William (1988) suggests that teachers do not have an in-depth understanding of what testing entails; neither do they use it well in the classroom. In a study conducted by Crooks (1988) and Black (1993b.) for example, the following weaknesses were found to be very common in teachers’ classroom testing approaches:

- ✯ classroom evaluation practices generally encourage superficial and rote learning, concentrating on recall of isolated details usually items of knowledge which pupils soon forget;
- ✯ teachers do not generally review the test questions that they use and do not discuss them critically with peers, so there is little reflection on what is being tested; and
- ✯ the grading function is over-emphasised and the learning function is under-emphasised and there is a tendency to use a normative rather than a criterion approach, which emphasises competition between pupils rather than personal improvement of each.

Other studies cited by Black and William (1988) confirm this general picture. Lorsbach, *et al.* (1992) and Rudman (1987), for instance, found in their research that although teachers can predict the performance of their pupils on external tests, their own assessments do not tell them what they need to know about their pupils' learning. Cizek, *et al*. (1995) and Hall and Webber (1997) also observed that teachers appeared to be unaware of the assessment work of colleagues and do not trust or use their assessment results. Additionally, reviews of primary school practices in England and in Greece by Bennet *et al*. (1992); Pollard, *et al.* (1994) and Mavromattis (1996) have reported that "teachers' records tend to emphasise the quantity of pupils' work rather than its quality*...*" (Black and William, 1988, p.11). The above situations are reflective of what pertains in Ghana educational system. Indeed, this remark is just my opinion since there is the lack of relevant research in Ghana.

Research by Firestone, *et al*. reported in Winter (1999, p.779) illuminate ways in which teaching is frequently geared to examinations rather to implementation of planned curricula. They discovered that teachers introduce explicit test-preparation activities, using items on the tests and explaining to pupils how the tests are scored and how to do well on them, and that teachers reported giving more emphasis to certain topics (e.g. number relationships and measurement) that would be on the test. All these, in my opinion, appear to be a neglect of the implementation of curriculum as a whole.

Woods *et al*. (1998) in a related study, found that teachers appeared to be steeped in a conventional view of what mathematics is and how to teach it. They said that assessments that challenge that view are likely to be undermined by conventionally oriented teachers. Why this conclusion? According to them, this group of teachers could prepare pupils for complex questions that require constructing responses by providing simple algorithms to follow that undermine the intent of the question and lead to teaching to the test.

Perspective in implementation of curriculum

A number of views have been expressed on the implementation of curriculum standards. Saylor, *et al*. (1980) have defined instruction as the implementation of the curriculum plan – that is, the actual engagement of the learners with the planned learning opportunities. They contended that the curriculum planning process necessarily includes making decisions regarding instructional modes with suggestions as to resources, media, and organisation, thus encouraging flexibility and more freedom for the teacher(s) and pupils. Teachers and pupils should be free in the implementation of the curriculum plan. Thus, effective curriculum plans will not prescribe instructional procedure and materials; rather, they will describe alternative instructional models and suggest a variety of instructional materials.

Swann and Brown (1997) found that in Scotland, teachers are accustomed to working in a centralised system, and generally, there has been a relatively high level of acceptance of a non-statutory national curriculum. According to them, evidence for teacher acceptance includes research findings from the official evaluation (SOED, 1994: Harlen and Malcolm, 1994: Goulder et al., 1994). Aside of doubts about the value of national testing, explicit criticism of Scotland's National Curriculum seems to have focused on such

issues as teacher workload, the pace of change, and questions of detail rather than on more fundamental issues of ideology and theories of learning.

Also, Swann and Brown (1997) discovered that the 5-14 programme focuses on Scotland's traditional broad curriculum areas. It is much less a syllabus than a framework of curriculum and assessment concepts, with distinctive priorities which include:

- ✯ The need to make judgements about pupils on the basis of multi-dimensional elements of performance rather than global measures
- ✯ The importance of differentiation using systematic formative assessment of individuals
- ✯ A formulation of the curriculum as objective-based with a linear model of attainment for each aspect of performance.

Teachers' thinking about their own teaching of their pupils determines what they do in classroom. Tomlinson (1989, p.157) in support of the above view articulated thus "In one form or another … the idea of human persons as active, selective interpreters and construers is by now well-grounded and widespread in modern social science".

While this assumption may be common in social science, it is often not shared by politicians, who tend to assume that the implementation of a central government initiative, such as a national curriculum, is a matter of hiring consultants to develop a body of ideas for implementation, then publishing these ideas for teachers to utilise or deliver in the classroom, with support of in-service training and coercive and/or incentive measures to encourage teacher-co-operation. Swann and Brown (1997) critically asserted that despite wide consultation and general levels of practitioner acceptance, 5-14 is still essentially a top-down initiative, and its translation from policy to practice will be subject to the difficulties apparent in the histories of similar schemes. Pratt and Silverman, (1988, Ch.1) seem to support this assertion by Swann and Brown when they stated that:

> It can also be argued that policy, quite simply cannot be translated into practice in the straightforward manner often assumed to be possible, because implementation almost inevitably leads to unexpected or unintended consequences.

If one accepts the idea that teachers' thinking is a crucial dimension in the introduction of curricula initiatives, then how to gain access to that thinking becomes an important concern. The research by Swann and Brown (1997) offers new evidence to the debate about situated cognition (Brown *et al*. 1989). It supports the argument that an initial emphasis on decontextualised formal concepts, rather than on existing activities and perceptions of the learner, is unlikely to lead to learning or, in this case, the successful implementation of a national curriculum. This argument has profound implications not only for the idea of delivering curriculum content to children, but also for the ways in which National Curricula are devised and developed for use by teachers. A perspective (e.g. Berman, 1986) – offered as part of a critique of power perspective (power perspective according to Firestone *et al*. is a situation where actors at each level as relatively independent agents with their own interests, possess resources that can be used to influence or deflect the persuasive efforts of others) – suggests that the real challenge of local implementation is learning. According to him, central policies often ask people at lower levels to do things they do not know how to

do, and aggressive punishment will not facilitate the implementation of changes that people do not understand. In fact, according to Cohen and Barnes (1993, p.207),

> Policy makers … are often blissfully ignorant of the learning that their creations entail for enactors. But policies and programmes regularly propose novel purposes. If they did not, they would be completely redundant. Some learning is required to achieve any new purpose.

Apart from the prospects of successful implementation of curriculum standards, research studies indicate that there are obstacles in the process. One of such studies is Johnson (1996). He categorically maintained that difficulties are encountered in the implementation of selected topics in mathematics – effectiveness of in-school planning, consideration of the nature of whole-school/department and individual teacher planning and associated review procedures, especially the extent to which teachers were basing these on NC documents. One other diagnosis of implementation failure was that central governments lacked sufficient power – in the form of desired resources or effective constraints – to shape local responses (e.g., Cohen and Spillane, 1993). The practical response to this diagnosis has been to introduce policies that increase centrally deployable sanctions. Academic critiques have usually emphasised the probable or actual negative unintended consequences of such deployment of sanctions (Corbert and Wilson, 1991; Murnane and Cohen, 1986). According to them, the English-Welsh version of this is the legislatively prescribed National Curriculum and associated testing procedures, which, for the first time, provided policy levers for the central government to directly influence curriculum content in schools.

This review has clarified the concept of curriculum, and explored views that people hold about the influence of curriculum change on classroom practices, in terms of teaching and learning of mathematics. It emerged very clearly that official statements of curriculum standards, however clear and admirable they might be, are unlikely to be translated into classroom teaching and learning practice unless many supportive conditions are in place. Furthermore, it also emerged that teachers and pupils tend, in response to the importance placed on examination results by the public, to shape their classroom practice more in response to the examination questions they anticipate than in response to official curriculum standards.

Methodology

General methods for answering the research questions

In order to establish the link between BECE papers and the curriculum standards I analysed some past BECE examination papers. The choice of the examination papers enabled me to explore how far the questions reflected the curriculum standards, as well as to explore any changes in terms of content and structure since the introduction of the curriculum standards. I was convinced by Firestone *et al*. (Winter, 1999, p.779) who illuminated ways in which teaching is frequently geared to examinations rather to implementation of planned curricula. They discovered that teachers introduce explicit test-preparation activities, using items on the tests and explaining to pupils how the tests are scored and how to do well on them, and that teachers reported giving more emphasis to certain topics (e.g. number relationships and measurement) that would be on the test.

Analysis of the Examination Questions

In any official or national system that is supposed to be used publicly (e. g. the BECE of Ghana), there is an obvious concern about how well the system operates: Does it work well? It is of course a personal judgement how well is well enough. In the case of this research, the analysis of the examination questions provides information for the establishment of the link between BECE papers and the curriculum standards.

The 1992 Paper

In this paper the first question asked pupils to solve an algebraic expression of the form $5x - 3(x-1) \geq 39$. This question seems to test the manipulative skills of the pupils, since the major task of solving this problem is the ability to remove the brackets and rearrange like and unlike terms, taking account of the inequality sign. The same question also asked pupils to make 't' the subject of the relation $V = U + t$. The approach to solving this equation is not quite different from that of the earlier part of the question. This question does not seem to be related to any of the five curriculum goals, the pupils would only have to execute the procedures of re-arrangement.

The second question provides pupils with information about percentages of income tax and property tax that can be deducted from workers salary. Pupils were demanded to find the percentage of a given amount. This question tasks the pupils to apply problem-solving skills. It is also to encourage real-world applications. Thus, it is likely to fall under the category of making meaningful mathematical connections.

Question 3 was on geometry and transformation. The pupils were asked to plot given points on the *x-y* co-ordinate plane and find the images of these points by reflecting them. This question requires the application of the concept of reflection. The task involved yields information about the extent to which pupils have integrated their knowledge of geometric concepts, hence this question is likely to be the type that requires application of concepts of space and measures.

The fourth question showed the distribution of the masses of pupils in a school. The pupils were asked to draw a bar chart for the distribution. This question explores the experiences of the pupils in collecting, organising, displaying, and interpreting data as well as making decisions. Thus the question encourages the use of practical activities and of making meaningful mathematical connections in relation to handling data.

The final question was on the construction of a triangle with the use of a pair of compasses and a ruler only. Even though the question appears to be requiring purely routine procedures, the geometric descriptions given were not related to real and practical objects. One would have expected references to be made from pupils' locality like 'the corner of a bedroom', 'the corner of a tuning fork' (triangle) and so on.

The 1999 Paper

The 1999 BECE is a recent paper set after the introduction of the new standards. With its 'modern' nature, one would expect its items to immensely reflect the aspirations and goals of the standard document. What is it then?

Question 1 was in two parts. The first part mentions two boys who have been given an amount of money to share. One had a specified amount more than the other. Pupils were asked to find each of the boys' share. The second part was much like the first. It was stated that "A trader paid ¢1,500.00 for 6 drinking cups. One of the cups got broken. He sold the remaining 5, making a profit of 10%". (¢ is the symbol for Ghana currency, called the cedi). The pupils were expected to calculate the:

(i) cost price of each of the six cups

(ii) selling price of the five cups and

(iii) profit made on each cup.

Apart from its requiring the routine procedures of calculating selling and cost price as well as percentages, this question requires pupils to apply the concepts of addition and subtraction. The pupils are expected to also make an understanding and develop logical reasoning about the situation. The use of practical activities and the development of problem-solving skills have been incorporated in this question – the buying, selling and sharing with familiar currency with known objects testify.

Question 2, which has been subdivided into three parts, is completely different from Question 1. The first part asked pupils to solve a given inequality, the second part tasked them to find the value of the expression $2x - 3y$, given $x = 1/4$ and $y = -1/2$.

The third part gave statistics of pupils in a class who took an examination in mathematics and science. It gave the breakdown of passes and non-passes and asked pupils to find how many passed in mathematics and the probability of meeting a student who passed in one subject. The first and second parts of this question seem to examine pupils' routine procedures in dealing with inequalities as well as the techniques of substituting variables to obtain a value, and all these in my opinion involve, perhaps, mainly arithmetic computation or the execution of an algorithm and could be judged as not fitting any of the five curricula goals listed at the beginning of this analysis section. In support of this, Firestone, *et al*. (1999, p.782) argue that problems like fractions to reduce or polynomials to factor are designed to help pupils master an operation or procedure. They maintain that these never provided opportunities for analytical reasoning. However, in the third part, attempt has been made to incorporate some real-world problem and hence assessing pupils' use of practical activities and problem-solving skills.

Question 3 is purely geometry. The first part of the question demanded pupils to construct a named triangle and also to construct a perpendicular from one vertex to meet one line. The second part asked pupils to calculate the area of the triangle constructed. This question looks almost like the fifth question of the 1992 paper. However, more mathematical thinking is involved in this paper. The pupils are to recall the procedures of constructing a perpendicular as well as the ideas/concepts of area of a triangle and apply some manipulative skills to calculate the area. Apart from the question requiring purely routine procedures, it also requires the pupils to apply some concepts.

Like question 3 of the 1992 paper, the fourth question of this paper was also on geometry. However, this question excluded *'transformation'* and rather demanded pupils to do practical measurements of two given angles using a protractor. One other interesting feature of this question is that pupils were tasked to identify an angle name (e.g. *alternate,*

vertically opposite, corresponding e.t.c.) common to two given angles and also to state a relationship (e.g. *parallel, perpendicular,* etc) between two given lines. This aspect, I think really tested the extent to which the pupils have grasped of basic geometric concepts. This question is concerned with shape and space and measure, but apart from limited practical activities does not seem to relate directly to any of the suggested curriculum goals.

The last question was on *handling data*. The question has been framed as below:

*The table below shows the marks scored **out** of 10 by some candidates in a test.*

Marks	1	2	3	4	5	6	7	8
No. of Candidates	2	3	5	7	8	13	7	5

(a) From the table above, find
(i) the modal mark
(ii) how many candidates took the test
(iii) the mean mark

(b) If 20% of the candidates failed,
(i) how many failed?
(ii) what is the least mark a candidate should score in order to pass?

This question has a lot to offer as far as the standard themes are concerned. One needs to understand what a mode is before one can find the modal mark. Interestingly enough, some pupils do define mode as the *highest frequency,* instead of the *mark or score with the highest frequency.* If the former definition is taken then one should not be surprised to see pupils writing 13 instead of 6 as the answer. This item therefore requires both critical classification and application of concept. The pupils are also tasked to make explicit connection and understanding of multiplication as *successive addition*. The pupils are to perform pair-wise multiplication (i.e. frequency times the mark - fx) and then sum them up ($\sum fx$) before they can tell how many candidates took the test. Generally, the question has presented a practical scenario (candidates' scores). It also demanded the use of problem-solving skills (if 20% of the candidates failed, how many failed?) and the use of logical reasoning (what is the least mark a candidate should score in order to pass?).

Discussions

Have the Curricula goals been met?

Prior to addressing this question, I must stress that the limited sample of my questions, do not permit me to make any generalized claims. Whatever claims I make therefore are limited to the coverage of my study.

Having analysed the above two papers of different eras, it is critical to reflect on the following questions:

- ✯ Has the *use of practical activities* been encouraged?
- ✯ Have *problem-solving skills* been developed?
- ✯ Has room been created to *facilitate discussion of mathematical ideas*?
- ✯ Have both the *development of logical reasoning* and the *meaningful making of mathematical connections* been encouraged?

Critical examination of the 1992 and 1999 papers reveals that there has not been any significant increase in encouragement of the use of practical activities, development of problem-solving skills, the facilitation of discussion of mathematical ideas and the development of logical reasoning and the making of meaningful mathematical connections. The wording and structure, as well as the content of the test items are almost identical, suggesting that nothing new has occurred. Furthermore, in the 1999 paper, relatively few items could be judged to be related to one or two of the current standards, but those that are judged to be related required the implicit or explicit performance of activities such as drawing a figure or reading results from statistical data.

Basic skills of calculation were tested, but a lot of times in isolation from applications of real problems. Some of the 'modern' contents were tested through questions, that appeared not to be properly focused (consider the first and second parts of question 2 of the 1999 paper for instance). On the whole, estimation, approximation, limits of accuracy and significant figures found a place on the standard documents, but were only occasionally examined. There were varieties of questions during the period under review. Indeed, this should have meant that a wider range of content of the Standard document could be tested. The move throughout this period, however, seems to have been, if anything, away from practical, activity-based assessments. There are question marks about the authenticity of these tests, since they do not suggest constituting an appropriate representation of the range of mathematical performance required by the curriculum. There is no clearly detectable difference between these two tests in their coverage of the new curriculum, although it is my strong personal impression that both these tests give a better coverage of the range of content of the curriculum than did those in the years before 1990.

Looking at the nature of the questions, it is suggestive that there were problems in assessing *shape, space and measures*. This, perhaps, is because of the lack of practical handling of shapes. Even in the other aspects of the curriculum, there seem to have been problems devising simple questions that allowed the assessment of aspects of the mathematics curriculum such as: recognising relationships, developing individualistic mental methods and solving problems through understanding and relating mathematics to purposeful contexts.

By their nature, the objective tests did not measure descriptive ability or powers of self-expression nor did it require interpretation of the answers. The quality of the written tests varied. Many of the test items used do not appear to be good as indicators of levels of National Curriculum achievement. Most of the questions tested simple recall of information and gave insufficient weight to understanding. For example, question 3 of section B of the 1999 paper asked pupils to use a pair of compasses and a ruler only to construct a triangle ABC with the various dimensions given. The same question required

the pupils to calculate the area of the triangle they had constructed. Here, pupils were rarely asked to justify their answers. Test items were designed away from real-world applications and there are no prompts to give written justifications for solutions.

Assessment of the skills of mathematical investigations was weak. The tests have retained the same format over the years (including the years before the new curriculum reforms). The assessments do not cover the process achievable target, *'Using and Applying'*.

Surprisingly, the use of calculators in the tests has been prohibited. The researcher is not sure how much longer this situation will continue. It should be emphasised that for some parts of the tests a calculator cannot be used for some questions, say in geometric drawing or co-ordinates. However, some of the questions in the examination papers can be tackled much more efficiently and rapidly with the support of a calculator. In any case, the exclusion of the use of the calculator does not have any significant influence on the pupils' tasks performance since almost all the questions tackled were fairly straightforward to be answered in the time available.

Limitation

The study drew upon very few past examination papers, and moreover, only two past papers, one each for the 'old' and 'new' systems were compared and contrasted. The scope therefore, is very limited for any generalisations to be established, hence there is the need for a further and more detailed study into this problem.

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